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TRIAL OF GRUSON'S TURRETS AT SPEZIA.

A TRIAL of Gruson's chilled iron armor, on a larger scale than has yet been attempted, commenced at Spezia on Tuesday, April 20. Before describing it, a few words of introduction may be desirable.

The Italian Government, having decided to erect two cupolas, each mounting two 120 ton Krupp guns, for the defense of Spezia, Herr Gruson was invited to construct them on his system, on the condition that he should make a test shield capable of bearing three blows from the projectile of the Armstrong 100 ton breech-loading gun. A test shield was erected at Spezia, and it received its first blow on Tuesday, April 20, the second on April 24, and the third on April 29, 1886.

This experiment is as completely opposite in character to that made with the special Schumann-Gruson cupola at Bucharest as can well be conceived. The latter was the attack of armor by comparatively small siege guns, whose fire was continued day after day from a short distance, and accurately directed. In fact, it was the regular breaching of a siege battery calling for peculiar powers of endurance (described in SUPPLEMENT No. 542, p. 8654). Soft armor is specially suited to resist a regular breaching attack, and both the structures tested were composed of soft wrought iron, although one had a hard steel face.

The exact opposite of all this may be said of this Spezia Gruson trial. Coast forts must expect to be attacked by the heaviest guns existing, but it may reasonably be supposed that very few blows will be actually delivered on their sides, for there is no likelihood of a ship being able to remain opposite a fort many hours, much less day after day. The ship's fire will consequently neither have the accuracy of siege fire, which is due to a short range and a fixed position, nor will it be very long sustained. The power to resist a few heavy blows is, therefore, what is called for. This power Gruson's armor of chilled iron admirably supplies. It forms the hardest shield possible. The metal transmitting the shock through its mass, it is impossible to injure anything covered by it, until the shield is broken and displaced. A blow greatly outmatching the resisting power of the shield may cause wholesale fracture, and leave a battery much more exposed to future fire than would be the case with soft armor, which, under such conditions, would let the projectile through it. In the case of Gruson's armor, the blow performs the maximum work on the shield and the minimum on the battery behind it, and in the case of soft armor the minimum of work on the shield and the maximum on the battery behind it. Consequently, it may be seen without further comparison that Gruson's shield is well suited to resist a few heavy blows, and is therefore well adapted to coast defense. It may generally be assumed that so long as a Gruson's shield stands up in front of a gun, that gun is safe against the next blow, even should that blow greatly outmatch the shield. And the safety of the detachment is secured in a peculiar degree by the fact that there are no bolt-heads to fly off and no langridge until the shield is broken up.

The chilled portion, which forms the main portion and receives the blow, weighs about 87,950 kg., or 86·56 tons, and is of the shape shown in Figs. 6 and 7. In the complete turret there are to be thirteen plates similar to this, and three broken by the two gun ports. The interior diameter of the cupola is to be about 10 meters. The shield is chilled white on its exterior face. The interior and other pieces of iron are mottled. The trial plate is fixed between two cheeks of iron, which are made large enough to obtain a good bearing on the masonry at each side, and thus to put the shield in as nearly the same condition as possible as that in which it would be placed in an actual turret. The recesses at the end of the plate are now made to fit, white metal not being necessary to key them together.

The firing took place in St. Maria Bay, in the Gulf of Spezia, where the shield was erected facing the sea. This shield being intended for a land fort, the experiment is conducted by General Giovanetti and the commission appointed for this branch of the work. The gun itself was in the hands of the navy. The manufacturing establishments interested in the trial were well represented, Herr Gruson and Captain Andrew Noble, C.B., being both present. Officers of several foreign powers, and representatives from Krupp and Schneider's works, also went to Spezia.

It will be seen that there are to be sixteen segment or sector-shaped shields in the turret, with two center plates forming the crown. The interior diameter is 10 meters—32·8 ft. The periphery is not a circle, but is formed of sixteen arcs of circles, each struck with a radius of about 15 ft. or 16 ft., giving an outline suggestive of that of a pomegranate. Of the sixteen plates, thirteen are similar to the shield under trial, each weighing about 87,950 kg., or about 86·56 tons. The remaining three are lighter, being pierced by the ports, the lightest being that between the gun ports. The thirteen unpierced plates will thus weigh about 1,100 tons. The two center or crown pieces weigh together 130,000 kg., or 128 tons. The total weight of the armor is over 1,400,000 kg., or 1,450 tons. This leaves 211 tons for the three pierced plates, two of which will be something over and the other something less than 70 tons. The entire running weight of shield—1,450 tons—is to be supported on an iron ring, worked by hydraulic machinery. The projectile was intended to strike the shield in the same way as it would if the path of the shot were inclined downward at an angle of 1 deg. and the shield standing on a horizontal base. For this purpose, as the gun fired slightly upward, the shield is, as it were, tilted very slightly forward, that is to say, forward to the extent of 1½ deg. in comparison to its position set on a truly horizontal base, 1 deg. for the supposed descending angle and ½ deg. for the difference in level of shield and gun. From what has been said as to the construction of the complete turret, it may be seen that the chilled plate actually receiving the blows was the only part of the tar-

FIG. 7.

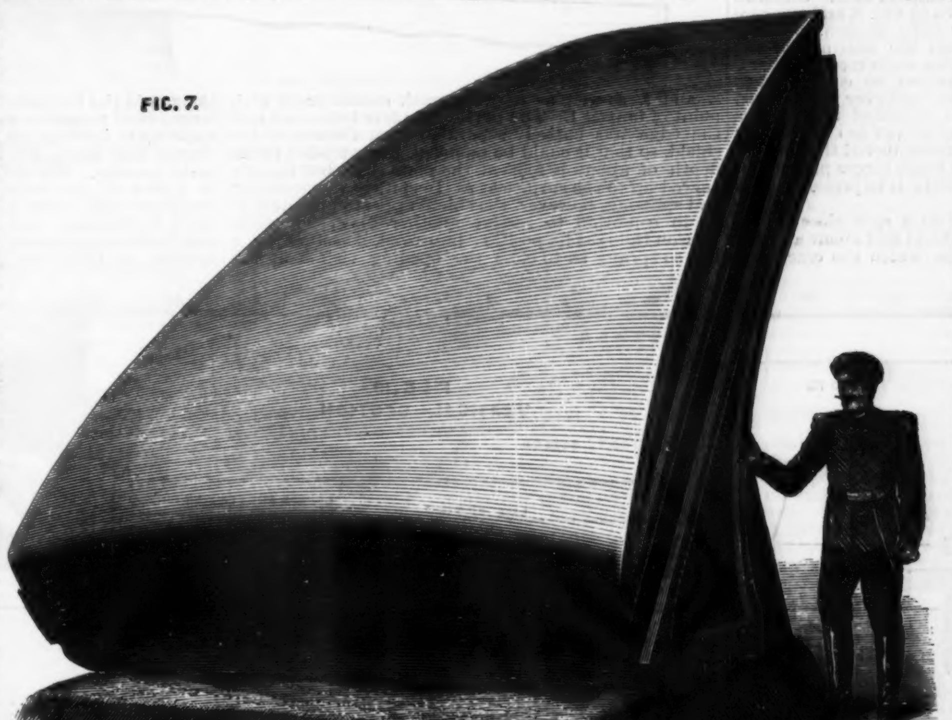


FIG. 6

GRUSON'S ARMOR.

get which corresponds to the turret; all other parts were substitutes. For example, the two large iron side pieces served to give a bearing on the masonry nearly corresponding to the support which would be afforded by the contiguous portions of the turret, which should be smaller in area, but more rigid than masonry of the same extent. The mottled iron piece at the top of the shield did duty for the circular crown of the turret, while the mottled piece at the base took the place of the plate forming the base of the turret.

The projectile was in each case a Krupp steel hollow projectile forged and hardened. The form and dimensions are shown in Figs. 13 and 14. Tool marks were visible from base to point. The projectile had, of course, been hardened subsequently to being tooled. There was a screw base plug somewhat resembling our own. The actual angle of incidence of the first projectile with the tangent to the plate face at the point struck was 40 deg., and the blow fell a little (8 inches) to the right of the middle line, and about as much above the designated point.

The projectile of the second round struck a few inches to the right, and high of the point aimed at—that is, it struck rather nearer to the point of impact of the first round than was intended, with an angle of incidence of 44 deg. As on the last occasion, the projectile was nearly entirely broken up into small fragments. One piece, however, of about 56 lb. weight, was found; it had formed part of the base end. It is shown in Fig. 15. The quality of the steel appeared to be excellent. It was pretty hard throughout, though some metal in a softer condition than the rest was said to have been found about the center.

The effect on the shield of the first two shots is shown in Figs. 8 and 9. As will be seen in Fig. 8, the second shot made a more serious indentation than did the first one, the depth of it being about 4 inches, while that of round 1 was only 2 inches. Several cracks were found made and opened in the plate (see "2," Fig. 8). Some cracks, marked A, B, C, D, were opened as wide as 1½ inch, and in some places the surface of the metal was chipped off. One iron side piece was broken through. Fig. 9 shows the back of the plate with fresh cracks ε, γ, and δ, and a small chip off at B. One iron side piece was cracked, as shown in Fig. 8, and the supporting masonry was a very little shaken, so that a little space was opened behind the bearings of the shield. The plate in these two shots received a considerable shock. It must, however, be considered to have stood admirably. No shield had ever yet received two such blows as this. The weight of the shield is great, so that the striking energy per ton is not very large. It must, however, be remembered that, owing to the excellence of the steel, a much larger proportion of the striking energy of projectile is impressed on the plate than usual.

The third shot was delivered on a spot close to the center line running down the shield and about a meter from round 1—see Fig. 17—on which the cracks are shown in the front of the shield by continuous lines, and on the back in dotted lines seen through as if the shield were transparent. The angle of incidence being more oblique—34°—than before, the indent of the projectile was less, being about 1½ in. The projectile flew into smaller pieces than before apparently, but the blow was sufficient to crack the shield, which is much thinner here, in lines shown in Fig. 17 as m, n, o, p, q, r, s, and t, as well as a small crack connecting q with point of impact 1. The portion of plate between t and the edge was entirely separated from the rest of the shield, so that it could be removed. It extended to the depth of about a foot at the plate edge, but rapidly curved up to the surface at t. In spite of this cracking and splitting, however, the shield appeared not only to be in condition to receive another blow, but Herr Gruson thought its position improved, inasmuch as it had so sprung as to close the opening visible at the last round, and was therefore now better supported. In the inside, cracks η, $\varkappa$, ζ, θ, and λ (see Fig. 18) were formed, and two very small pieces were detached near λ (see Fig. 18), where the plate had obviously felt the blow severely, the fragment in the center marked $p\,r$ projecting slightly, and the cracks there being deep and opened.

The firing conditions were as nearly as possible the same as in the two previous rounds. The third Krupp forged steel projectile was employed, its weight being made up to 1,000 kg., or 2,204·6 lb.—nearly a ton. The charge was again 375 kg.—826·7 lb.—of Cologne prismatic powder. The striking velocity was 536·1 meters or 1,758·9 ft. per second; the striking energy being therefore 14,651 meter tons, or 47,306 foot tons. Pressures in the bore were registered as 2,010, 1,973, 1,985, and 2,025 atmospheres, the mean being 1,998 atmospheres, or 13·11 tons per square inch. The charge,

FIG. 11

HORIZONTAL SECTION THROUGH A. B.

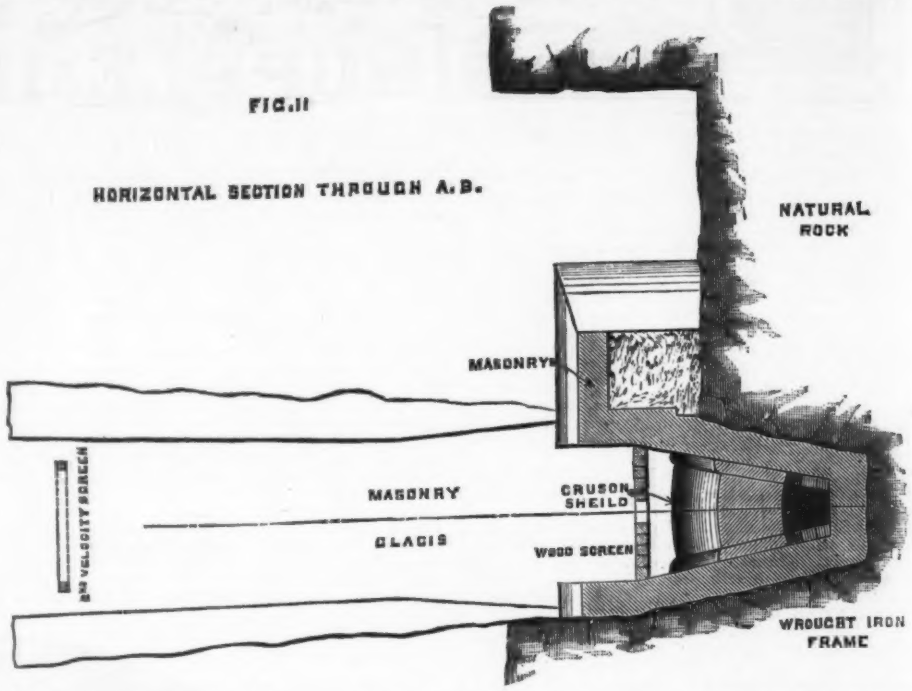
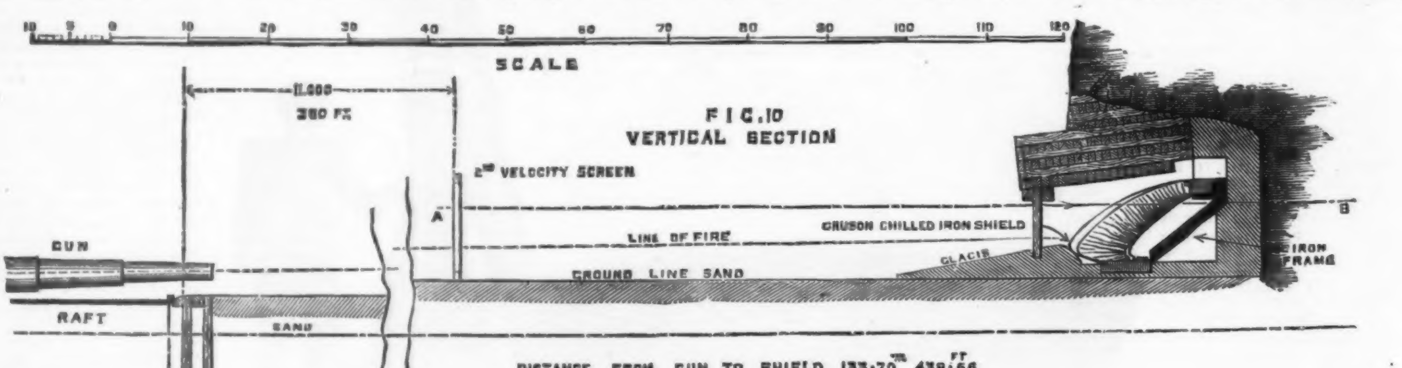


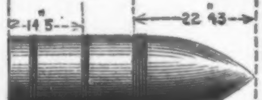
FIG. 10

VERTICAL SECTION



DISTANCE FROM GUN TO SHIELD 133·70 M 438·66 FT

FIG. 13.



KRUPP-STEEL-PROJECTILE -FORGED-

FIG. 14.

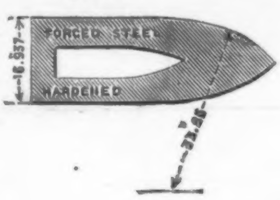
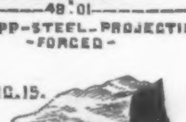


FIG. 15.



LARGEST FRAGMENT ABOUT 55 LBS WEIGHT

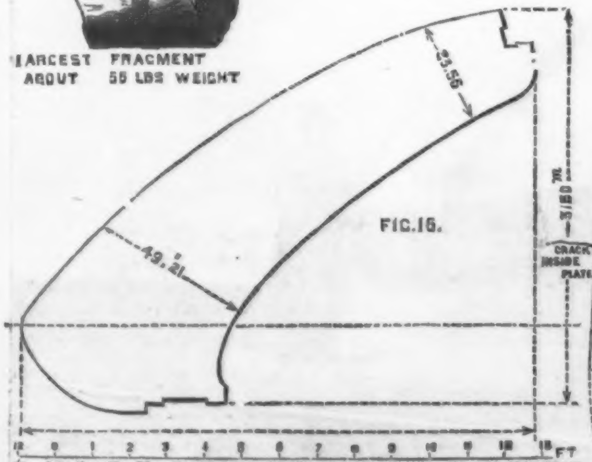
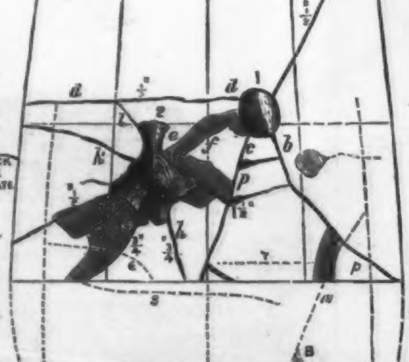


FIG. 16.

FIG. 8.



FRONT OF SHIELD DEVELOPED

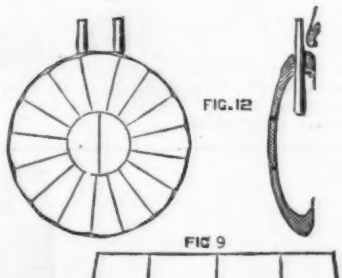
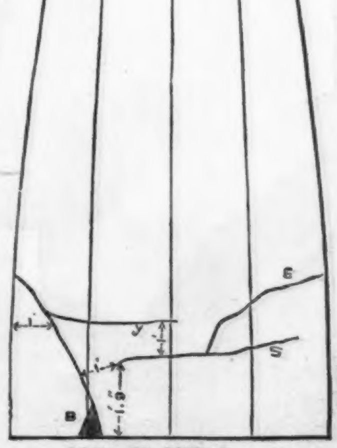


FIG. 12

FIG 9



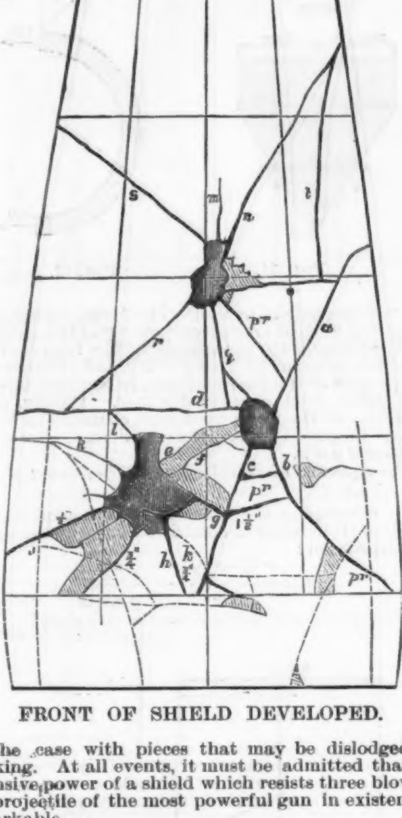
BACK OF SHIELD

GRUSON'S ARMOR.

as in the preceding rounds, was made up in four cartridges ribbed longitudinally with serge rolls, so as to make the charge lie in the bore with a space round it.

On the whole, the shield acquitted itself admirably, for it had borne the three blows without any piece of any importance being dislodged in the inside. The small pieces, from parts shown shaded, which came off appear to have been shaken or dropped down rather than flown out, and a detachment of men behind this shield would have remained uninjured. Bolt heads generally fly with violence, because their fracture is due to a strain on the bolt, which causes them to spring into the interior. This does not seem to

FIG. 17



FRONT OF SHIELD DEVELOPED.

be the case with pieces that may be dislodged by cracking. At all events, it must be admitted that the defensive power of a shield which resists three blows of the projectile of the most powerful gun in existence is remarkable.

The following table gives the details as to velocity and energy of each round:

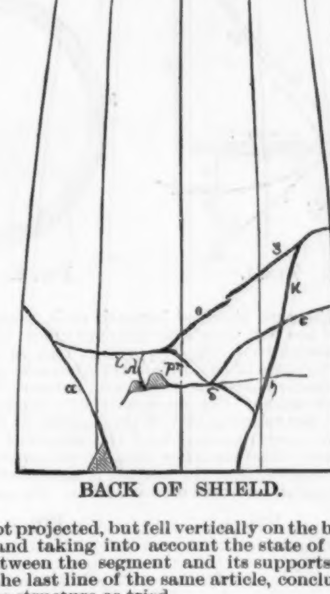
Ballistic Power of 100 *Ton Breech-loading Armstrong Gun Fired at Spezia on April* 20, 24, *and* 29, 1886.

Number of round.	First.	Second.	Third.
Velocity at muzzle in meters	541·2	541·9	540·1
" " in feet	1775·6	1777·9	1772·0
" at 85 meters in meters	538·6	537·3	537·5
" at 278·9 feet in feet	1767·1	1769·4	1763·5
" at point of impact in meters	537·2	537·9	536·1
" " " in feet	1762·5	1764·8	1758·9
Energy at muzzle meter tons	14,929	14,966	14,871
" " foot tons	48,207	48,326	48,019
" at point of impact meter tons	14,700	14,747	14,651
" " " foot tons	47,499	47,629	47,306
" " " per in. cir. foot tons.	892·8	896·9	888·6
Perforation in wrought iron at striking, inches.	31·2	31·2	31·1
Angle of incidence of projectile with tangent to shield	40 deg.	44 deg.	34½ deg
Energy in foot tons at impact per ton of shield.	548·9	550·1	546·4

The following is the *resume* of the official reports of the trials. The segment tested was proved to possess satisfactory resistance, because, having received blows from three projectiles of cast steel, each with a mean energy of 14,700 meter tons, reducing to 163 meter tons per ton of segment, and notwithstanding the unfavorable conditions of installment under which it received the third blow, it preserved so much of its essential strength as defensive armament, still being in good condition as regards its inner surface.

Consequently, as far as regards the fact that pieces were detached from the interior surface of the segment after the third blow, the structure, in literal construction of the terms of the first line of article 4 of the supplemental contract, could have been rejected, the commission, considering that the small pieces detached

FIG. 13



BACK OF SHIELD.

were not projected, but fell vertically on the bottom segment, and taking into account the state of disconnection between the segment and its supports, provided for in the last line of the same article, concluded to accept the structure as tried.

The projectiles were submitted to examination after the trials, and were also found to be of the best quality. —*The Engineer and Revista di Artigleria e Genio.*

HIGH SPEED ENGINE.

IN the Liverpool exhibition, Messrs. Robey & Co., of Lincoln, among other exhibits, show a high speed engine, illustrated herewith, which has been specially designed for working electric light machines on board ship, or for any other condition in which great power is required in a small space. The engine is designed to work with steam of high pressure and at 150 to 350 revolutions per minute, all the wearing parts having large surfaces. The method of lubrication is the principal feature of novelty. The lower part of the base plate is shaped so as to form an oil well, into which the big end of the connecting rod dips at each revolution. The under side of the connecting rod strap has attached to it an open "licker," communicating with the oil grooves in the brasses. This licker, passing rapidly through the oil, forces a small quantity into the crank bearing at each revolution. The remainder of the oil is thrown upon the small end of the connecting rod and on to the slipper guides. At the cylinder end of the guides is a large hole, ¾ in. in diameter, from which a pipe takes the surplus oil back to the well. A hinged cover incloses the crank pit and prevents the oil splashing over. The engine is 6 horse power nominal; the crank pin is 3⅛ in. in diameter by 4 in. long. The main journals are 3½ in. in diameter and 7 in. long. The bearings of these journals are brought close up to the crank webs in order to avoid bending strains. When used for electric lighting, the engine is mounted on a cast iron base plate, on which the dynamo is also placed. The base plate is provided with lugs and adjusting screws, so that the driving belt can be tightened without stopping the machinery.—*Engineering.*

THE COMPOUND ENGINE COMPARED WITH THE HIGH PRESSURE CONDENSING ENGINE.

By F. H. WALTON.

FROM the promiscuous uses to which the compound engine has been put of late years, it may be surmised that there are many steam users—and engineers as well—who do not know its relative value; for this reason the present paper is written to call attention to the subject.

It is well known that in the early history of the steam engine, the compound engines of Hornblower and Wolfe struggled for places as competitors; but by the *superior performance* of the common condensing engine using steam expansively, it was found that there was an absolute waste of power in the compound engine. When everything else was equal, this wasted power amounted to that acting as *back pressure on the high pressure cylinder;* and to-day this important item has not been overcome, in spite of the improvements said to have been effected in the compound engine.

In the Cornish mines, the engineers used tolerably accurate means of testing and comparing their engines; the amount of water raised to a given height by a certain volume of steam under a given pressure was a test of the quality of the engine. They found that the more expansively they used the steam, the greater was the performance of any particular engine. The boiler, too, came in for its share of attention, and the Cornish boiler, with its return flues, only succumbs to the modifications of the same boiler used at the present time.

When engineers were so intent on getting the greatest amount of work from given weights of fuel, the competitors could not, for their reputations' sake, find places for a compound engine, and it met its fate in its first stages of infancy, its merits having been duly considered and thoroughly understood.

We only need a few examples to show *how much inferior* is the performance of a compound engine using the same amount of steam as another simple engine, when the combined cylinder capacity through which the pistons travel in a given time is equal to that of another engine in which the steam of the same density is equally expanded before it is open to the condenser.

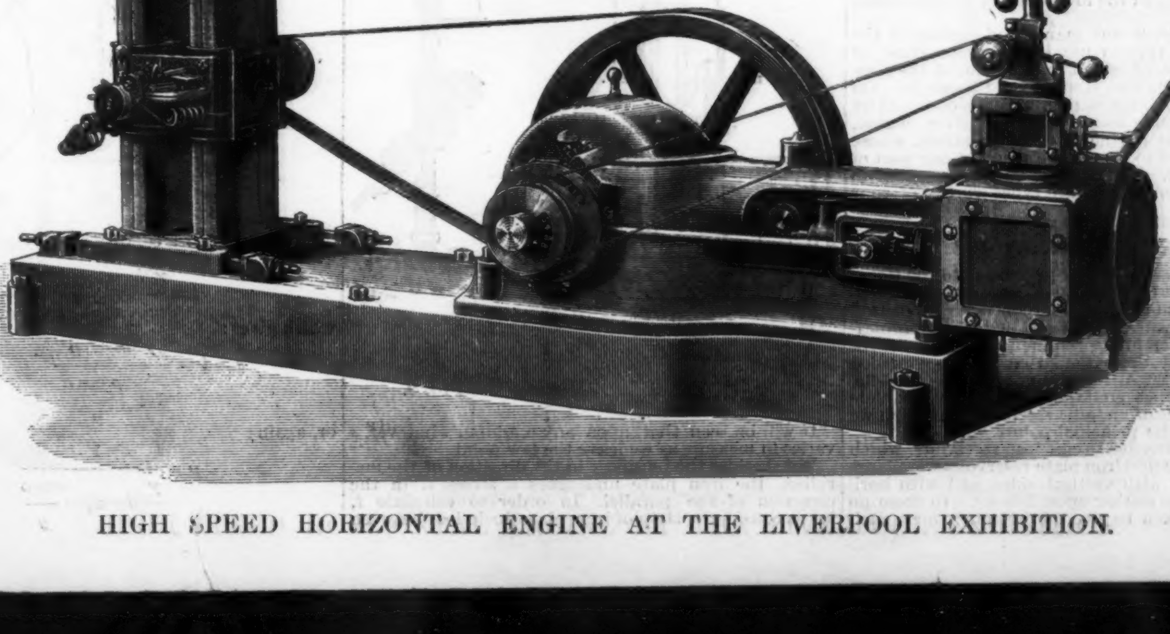
To begin with the high pressure cylinder of the compound engine, we will let it have an area of piston equal to 300 square inches, and let it commence its stroke under a pressure of 100 lb. per square inch. By cutting off steam at half stroke, we let it escape into the receiver or second cylinder under a pressure of 50 lb. per square inch. By making the second cylinder four times as large as the first, and giving the piston an area of 1,200 square inches, we would work this steam down to a pressure of 10 lb., that is 5 lb. below the pressure of the atmosphere, before we allowed it to escape into the condenser.

Under such conditions, the steam in the high pressure cylinder would act with a mean pressure of 87½ lb. per square inch. If there were no back pressure, and this piston were to travel through 400 feet per minute, the power produced would be equal to the force of 318 horses; because, according to the common mode of calculation, we have $\frac{300 \times 87{\cdot}5 \times 400}{33{,}000} = 318$ H. P. But the mean back pressure would be about 31 lb. per square inch, which would reduce the effect by 112 H. P.

We will follow the steam through the second cylinder, to find that, with everything considered, it would act with a mean pressure of 31 lb. per square inch. Then a piston having an area of 1,200 square inches, moving with a mean effective pressure of 31 lb. per square inch through a space of 400 feet per minute, will perform the work of 451 horses, according to the worked example here given below:

$\frac{1{,}200 \times 31 \times 400}{33{,}000} = 451$ H. P. But for the back pressure opposing the piston of the high pressure cylinder, we would have a combined force equal to the power of 769 horses performed by the two cylinders. As it is, however, it is minus 112 H. P., which must be deducted from the compounded type of engine.

In another example, let us add the two cylinders together, and allow the same amount of steam to pass through the one thus formed as there passed through the two cylinders of the above example, and let the one piston having an area of 1,200 square inches pass



HIGH SPEED HORIZONTAL ENGINE AT THE LIVERPOOL EXHIBITION.

through the same cubical space in a given time as did the two. We have the conditions as nearly similar as they can be made, and we can thus truthfully compare the merits of the two systems of using steam.

Whether we allow the piston speed to remain the same, and increase the area of the low pressure piston to 1,500 square inches, or increase the speed of the piston from 400 to 500 feet per minute, and allow the piston to remain as it is with 1,200 inches of area, we have precisely the same result as far as cylinder capacity is concerned. We have the same cubical capacity traversed by the single piston in the same time that it was traversed by the two pistons of the former example.

Let us, then, add one-quarter to the stroke of piston of the low pressure cylinder, and make its parts so strong that the pressure of 100 lb. per square inch will not injure it or any of its connections. This addition, being equal in cubical contents to the high pressure cylinder of the former example, gives us a new cylinder equal in capacity to the two. Now, if we allow the steam from the boiler to follow the piston through one-half of the additional part of the cylinder, and then cut it off, we have exactly the same quantity of steam that was used in the former example. This steam, thus being cut off at one-tenth of the stroke, allows the same grade of expansion to take place; and after traversing one-fifth of the stroke, the steam enters the cylinder at a point beyond which its capacity is equal to the low pressure cylinder of the former example; and the steam, having undergone one grade of expansion, as in the former case, enters the cylinder beyond this point at 50 lb., and is carried to the end of the stroke, expanding in the same manner and producing the same effect that it did in the low pressure cylinder of the first example. But the high pressure steam, acting in the additional part of the cylinder under a mean pressure of 87·5 lb., having traversed at the rate of 100 feet per minute, has given out the force of 318 H. P. As the opposite side of the piston has been open to the condenser during this part of the stroke, there has no deduction to be made for back pressure; and, owing to this circumstance, the simple high pressure condensing engine, using steam highly expansively, is only so much superior in its effects to the compound type as is the force lost by this back pressure while acting to oppose the motion of the high pressure piston of the compound engine.

As the piston follows to the end of the stroke during the remaining four-fifths, the result of the piston acting in two parts, when added together, amounts to the same thing as in the former example, excepting the lost 112 H. P. But the single piston has traversed 500 feet in one minute through a space which combines that of the two cylinders of the former example, but fully 16 per cent. of work additional has been performed with the same amount of steam. But in such a case, where high pressure steam is let on to a large piston, the piston, piston rod, and all their connections must be made sufficiently strong to withstand the shocks resulting from its use.

For stationary engines, where heavy balance wheels may be used to equalize the motion of the main shaft, the compound engine cannot be made to do work as economically as that of the high pressure condensing type of engine using steam expansively, when the *degree of expansion* is the same in all cases.

In marine engines, the compound type may in some cases be used to advantage; but it cannot long hold the place it holds to-day among engineers. It will surely be superseded by the simple form using high pressure steam expanded indefinitely, where one, two, three, or more steam cylinders will be used, and where the use of heavy balance wheels will be found to have advantages instead of objections, if the bulk of weight is thrown out into the rim to give the greatest possible momentum.

The improvements in the "modern marine engine" consist more in the use of high pressure steam and an improved boiler, and in the universal introduction of the surface condenser, than in the compound type of engine. By using high pressure steam expansively, less volumes of steam are made to do more work than formerly; the great loss occasioned by the *latent* heat of steam is thus considerably reduced.

In the above examples due allowance has been made for the extra rate of expansion derived from the superheating of steam. 31 lb. per square inch of pressure, as the mean result during the stroke of piston through the low pressure cylinder, may be a high estimate, which can only be obtained by the use of a good superheater; but it serves equally well for the sake of illustrating our subject, because the conditions were taken as equal in both cases. With less pressure in the low pressure cylinder, we have less work done, and also less back pressure against the piston of the high pressure cylinder. In practice, 6 to 8 lb. above the atmosphere, or a total of 21 or 23 lb., are the figures indicated mostly by the gauges placed between the two cylinders or on the receivers into which the steam of the high pressure cylinder of compound engines exhausts, and from which the low pressure cylinder takes its steam.

But at sea we have not many *good* engines of the simple condensing type in use, if we except those of the American rivers, of which the Pilgrim, of the New York and Providence line, is a splendid example. On land we have the Cornish engine, which is operated by the same kind of valve as the American river engine, and also the Corliss engine and its imitations, whose valves are arranged to cut off the steam at any part of the stroke required. Give these engines something to do at sea, gentlemen. They are types worthy of your ingenuity.

IRON PLATE RESERVOIRS.

DR. FORCHHEIMER recently presented to the General Assembly of German Technologists, who are occupied with water and gas, a note upon the construction of iron plate reservoirs, the object of his communication being to bring into prominence the labors of Engineer Intze and the patents that he has conceded the making of to F. A. Neumann, of Aix-la-Chapelle. In addition, the paper contained a tolerably complete study of the subject of metallic reservoirs, of which we shall recapitulate the principal points.

We shall omit reference to cast iron reservoirs, which are the older. The first iron plate reservoirs were large rectangular tanks, with vertical sides, and with horizontal flat bottoms resting upon T-irons. In these no precaution was taken to give the bottom a form such as to resist the stresses to which it was to be exposed. Besides, these reservoirs were much too heavy. In the second type, still generally adopted, the reservoir is cylindrical and the bottom is convex. By this arrangement the surface of the vertical sides is reduced, as is also the weight in the same proportion. Moreover, the weight of the iron bottom is less, since calculation shows that thinner plate can be used in this form.

In order to estimate the stresses that the iron plate is subjected to in a bottom of this nature, let us suppose it intersected by a horizontal plane, and let us

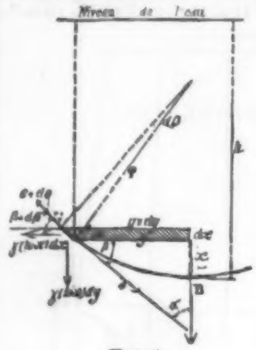


FIG. 1.

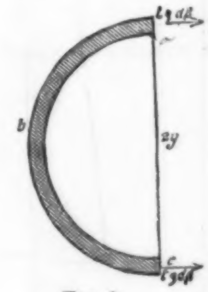


FIG. 2.

consider the part situated beneath such plane. This portion of the bottom will tend to fall under the action of the pressure that it is supporting; but, at the same time, in the plate of the entire circumference, there will develop elastic reactions which will balance the pressure of the water. Let us denote by s the tension of the plates per running foot of the parallel in the direction of the meridian, and by γ the weight of a cubic foot of water, and for other data let us consult Fig. 1. We shall suppose that the bottom is not spherical, but that it remains a surface of revolution. On projecting

FIG. 3. FIG. 5.

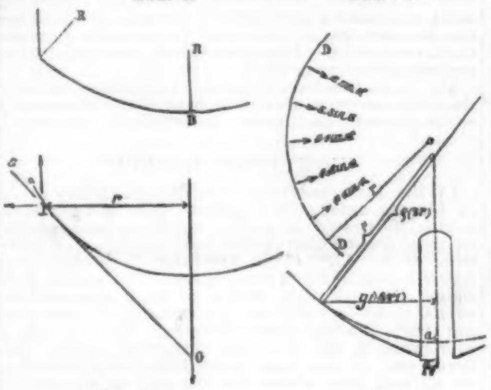


FIG. 4. FIG. 6.

the forces upon a vertical axis, we shall have the equation of equilibrium:

$$\gamma\,(h-x)\,\pi\,y^2 + \gamma\int_o^x \pi\,y^2\,d\,x - 2\,\pi\,y\,s\,\sin\beta = o$$

and as $\sin\beta = \cos\alpha$, we deduce

$$s = \frac{\gamma\,(h-x)}{\cos\alpha}\,y + \frac{\gamma}{2\,y\cos\alpha}\int_o^x y^2\,d\,x \qquad [1]$$

FIG. 7.

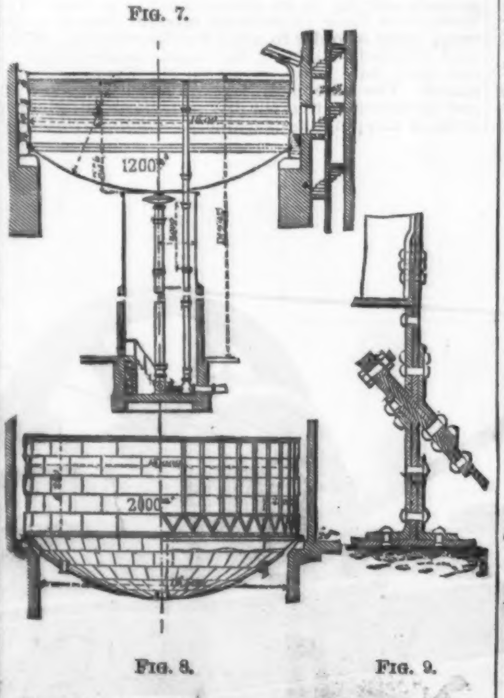


FIG. 8. FIG. 9.

It will be seen that, upon any meridian whatever, s varies in measure as we leave the low point.

But, besides the tension s in the direction of the meridian, the iron plate undergoes a stress, t, in the direction of the parallel. In order to calculate t, let us consider a strip of iron plate included between two exceedingly close semi-parallels. This will be in equilibrium under the action of the forces s, directed downwardly, of the forces $s + d\,s$, directed upwardly, of the two forces $t\,\rho\,d\,\beta$, applied at a and c (Fig. 2), and of the pressure of the water upon the element $a\,b\,c$.

The sum of the projections of all these forces upon the horizontal axis at right angles with the diameter,

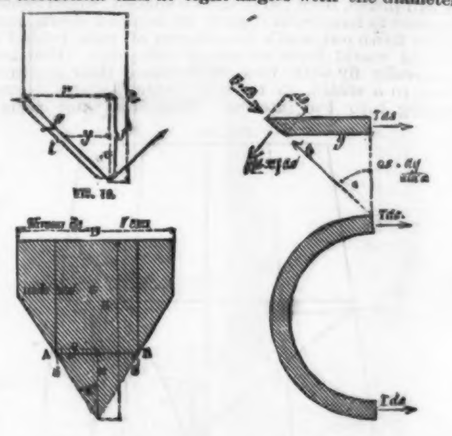


FIG. 10. FIG. 11. FIG. 12.

$a\,c$, will necessarily be null. The forces, $t\,\rho\,d\,\beta$, will be projected in their true magnitude; and it is easy to see that the sum of the projections of the forces s, from a to c, will be equal to $s\cos\beta \times 2\,y$, and the sum of the projections of the forces $s + d\,s$, in contrary direction, will differ from $d\,(s\cos\beta \times 2\,y)$. Finally, all the pressure of the water upon each element of $a\,b\,c$ will, when projected upon the same axis, give a force $\gamma\,(h-x)\,2\,y\,d\,x$.

The equation of equilibrium will be, then:

$$d\,(s\cos\beta \times 2\,y) + \gamma\,(h-x)\,2\,y\,d\,x - 2\,t\,\rho\,d\,\beta = o.$$

On developing the differential and employing the relation [1] in order to eliminate $d\,s$, we obtain the simple expression:

$$t = \frac{\gamma\,(h-x)\,y}{\cos\alpha} - \frac{s\,y}{\rho\cos\alpha} \qquad [2]$$

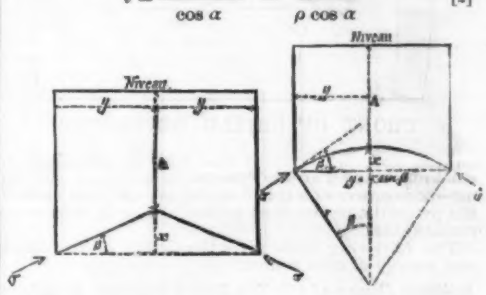


FIG. 13. FIG. 14.

As the low point is an umbilicus, the spherical surface is in its immediate vicinity, and, consequently,

$$\beta_1 = \frac{y_1}{\cos\alpha},$$

and, on making $x_1 = o\ y_1 = o$, we shall have at the low point:

$$s = t = \frac{1}{2}\,\gamma\,h\,\rho_1.$$

The equality of s and t in this case is evident, *a priori*, since here all the directions are those of the meridian and that of the parallel reduced to a point.

As it is necessary to always determine the thickness of the plates so that the greatest tension may be resisted, it would seem rational to give the bottom such a form that we should have $s = t$ everywhere.

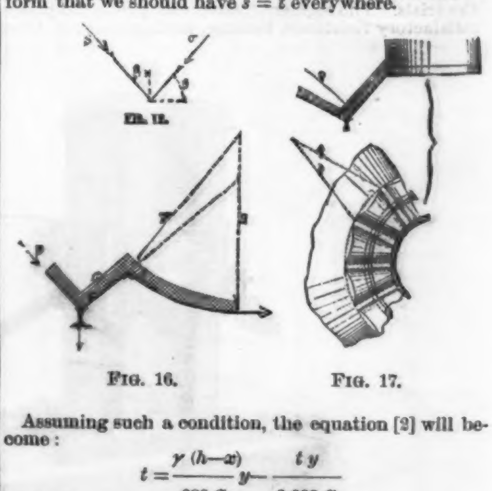


FIG. 15. FIG. 16. FIG. 17.

Assuming such a condition, the equation [2] will become:

$$t = \frac{\gamma\,(h-x)}{\cos\alpha}\,y - \frac{t\,y}{\rho\cos\alpha},$$

which gives:

$$s = t = \frac{\gamma\,(h-x)\,\rho}{1 + \dfrac{\rho\cos\alpha}{y}} \qquad [3]$$

or, again:

$$\rho = \frac{1}{\dfrac{\gamma}{t}\,(h-x) - \dfrac{\cos\alpha}{y}} \qquad [4]$$

We can, by giving the low point a radius of curvature ρ_1, graphically compose a meridian, s, of portions of an arc for which the formula [4] verifies itself. Prof. Intze traced such curves, and found in fact a slightly less weight of iron plate than for the spherical bottom.

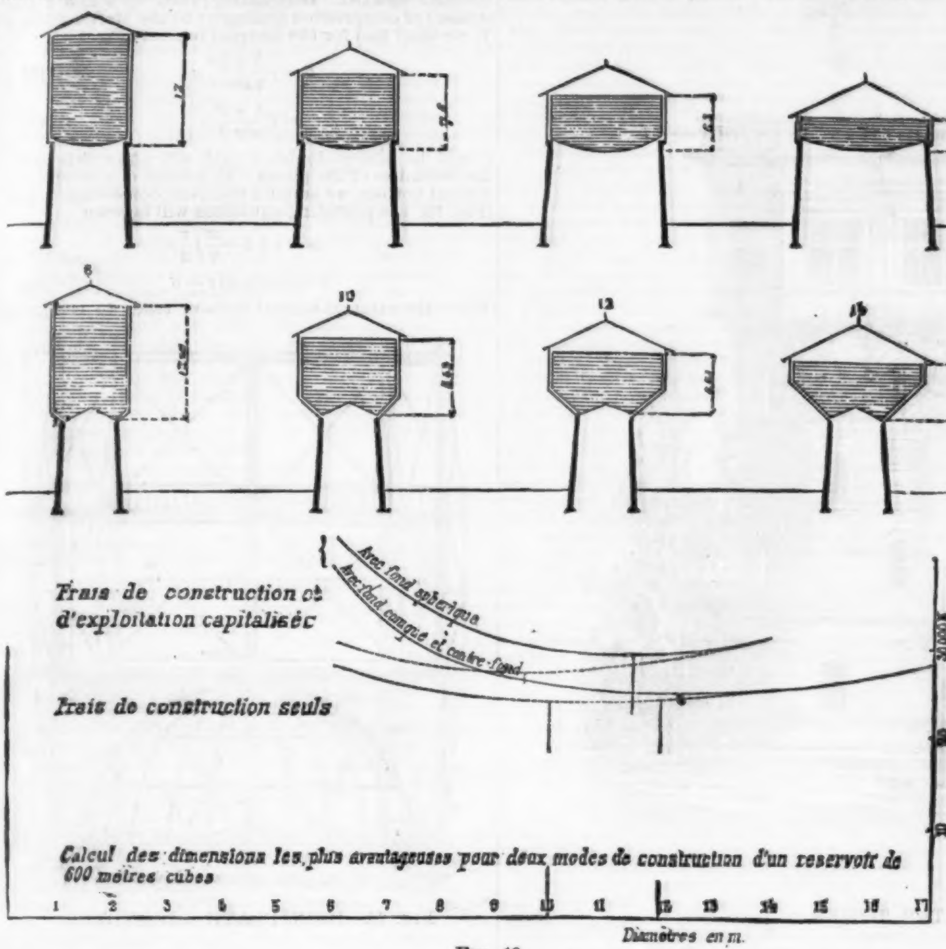


FIG. 18.

On the contrary, the net cóst was higher, for spherical bottoms have the decided advantage, in this case, of everywhere possessing the same curvature, thus permitting of all the plates being shaped upon the same form.

We have, then, only to return to the spherical shape. In this case $\rho=R$, and the application of formulas [1] and [2] will give:

$$s=\gamma\,(h-x)\frac{R}{2}+\gamma\frac{x^2}{2\,y^2}R^2-\gamma\frac{x^3}{6\,y^2}R. \qquad [5]$$

$$t=\gamma\,(h-x)\,R-s. \qquad [6]$$

These formulas can be further simplified by making a sufficiently approximate calculation. We may, in fact, suppose a parabolic curve that shall, throughout nearly its entire extent, be confounded with the meridian of the spherical bottom. But then $\int_0^x y^2\,d\,x$ will equal $\frac{x\,y^2}{2}$, and formula [1] will become:

$$s=\gamma\left(h-\frac{x}{2}\right)\frac{y^2}{2\cos\alpha}=\gamma\left(h-\frac{x}{2}\right)\frac{\rho}{2}$$

and as

$$\rho=R,\ s=\gamma\left(h-\frac{x}{2}\right)\frac{R}{2} \qquad [5a]$$

and

$$t\,\gamma=\left(h-\frac{3x}{2}\right)\frac{R}{2} \qquad [6a]$$

These last formulas show very clearly that s and t diminish in measure as we get away from the lowest point, and, besides, that s is always greater than t. It will suffice, then, to calculate s in order to determine the thickness of the plates; and, if we adopt a uniform thickness for the bottom, it will suffice to calculate s at the lowest point, which will give

$$s=\frac{1}{2}\gamma\,h\,R=t \qquad [7]$$

Reservoirs rest upon a circular support, generally of cast iron, which must be strong enough to support the thrust of the bottom without the aid of the cylindrical shell. Let G be the weight of the reservoir full of water, and D the stress of compression which acts upon the support. The equations of equilibrium in horizontal and vertical projection will give (Figs. 4 and 5):

$$D=s\sin\alpha\times r \qquad G=s\cos\alpha\times 2\,\pi\,r$$

whence

$$D=G\frac{\operatorname{tg}\alpha}{2\,\pi} \qquad [8]$$

For	$\alpha=$	30°	45°	60°	75°
we have	$\frac{D}{G}=$	0·0924	0·159	0·273	0·594

We shall finish what relates to the calculation of a reservoir with convex bottom by a remark upon the erection of a spiral staircase in the tower. In this case, the stress supported by the plates at the circle of penetration of the cylindrical shell and of the spherical bottom is notably increased. If the entire bottom be formed of a uniform thickness of iron plate, it will be necessary to modify the form of the meridian; for example, as shown in the diagram in Fig. 6.

We present herewith seven examples of the kind of reservoirs for which we have just given calculations.

Fig. 7 shows a 42,380 cubic foot reservoir constructed at Halle. In the first project, the annular support was too weak, and Mr. Intze had to strengthen it. In addition to this, he increased the pitch of the spherical bottom. In the Essen reservoir, of 70,000 cubic feet, perhaps the largest existing one of iron plate, Mr. Intze was likewise led to strengthen the annular support, and, as the nature of the soil brought about unequal subsidences of the masonry, he made the ring of wrought instead of cast iron. Figs. 8 and 9 show the mode of construction adopted.

In Figs. 21 and 22 is shown a water tower constructed for the city of Remscheid, and in connection with which Mr. Intze was led to make some researches that are the object of his patents, and that we shall make known.

As the sphere is not a developable surface, it is impossible to bring iron plates to this form without expanding certain parts and compressing others, from whence there evidently results a weakening of the resistance. Is it possible to overcome this difficulty, and at the same time effect a saving in cost, by discard-

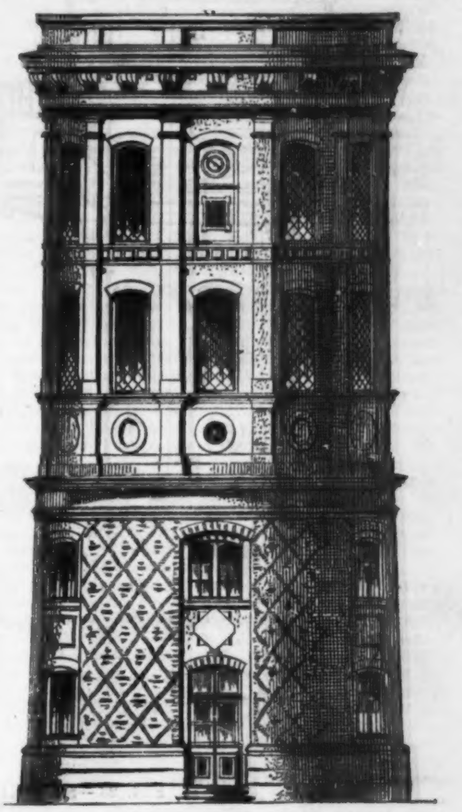


FIG. 21.—REMSCHEID WATER TOWER.

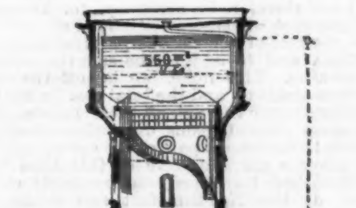


FIG. 19.

FIG. 20.—DUREN WATER TOWER.

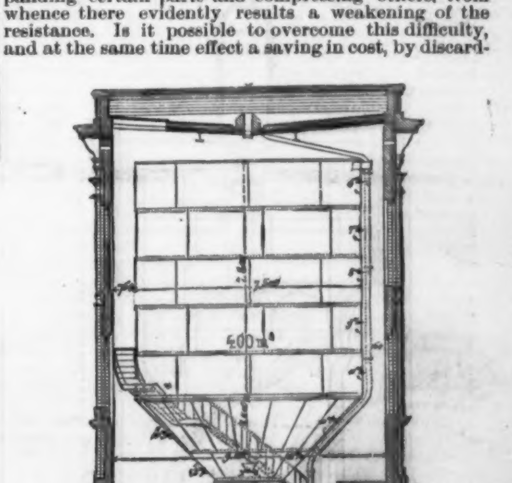


FIG. 22.—VERTICAL SECTION.

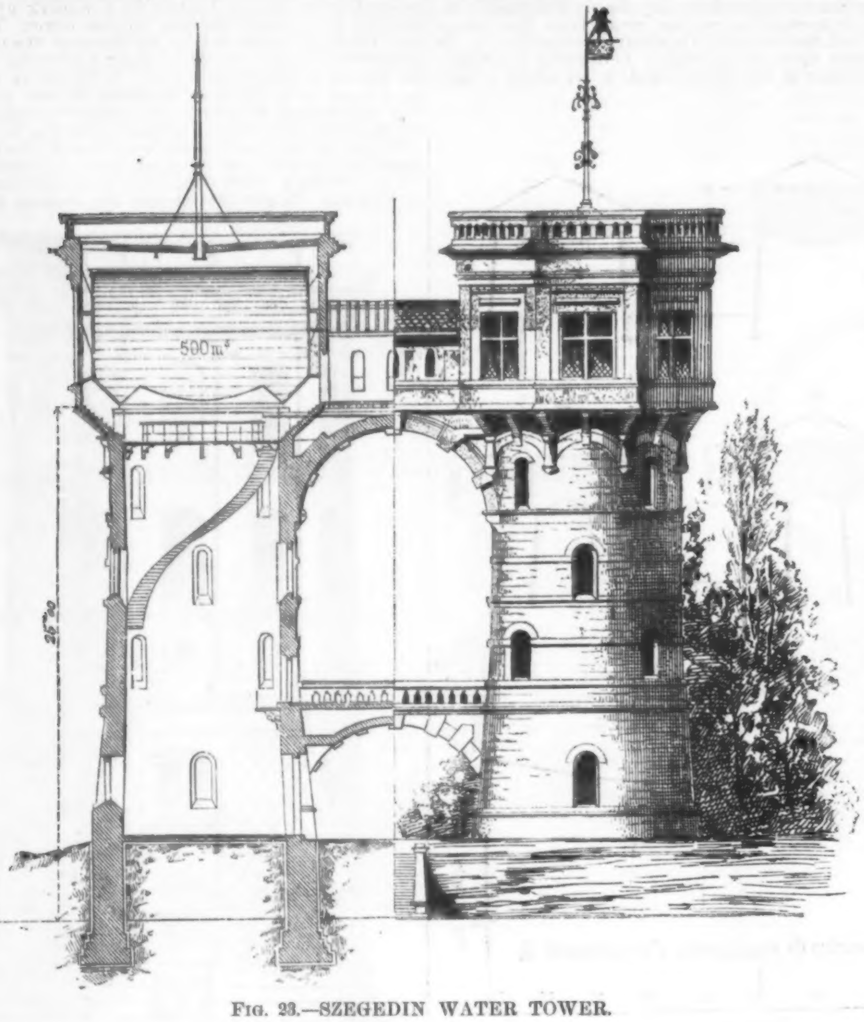


FIG. 23.—SZEGEDIN WATER TOWER.

ing the spherical form? The shape that at once suggests itself to the mind is the conical. In the case of a conical bottom held by an annular support, equations [1] and [2] become (Fig. 10):

$$s = \gamma \frac{l}{2f} y \left(h - \frac{2}{3} x\right) \qquad [9]$$

$$t = \gamma \frac{l}{f} y (h - x) \qquad [10]$$

s is maximum for $x = \frac{3}{4} h$, and t for $x = \frac{1}{2} h$. If we determine the strength of the plates from these values, we find that a conical bottom is 40 per cent. heavier than a spherical one having the same inclination to

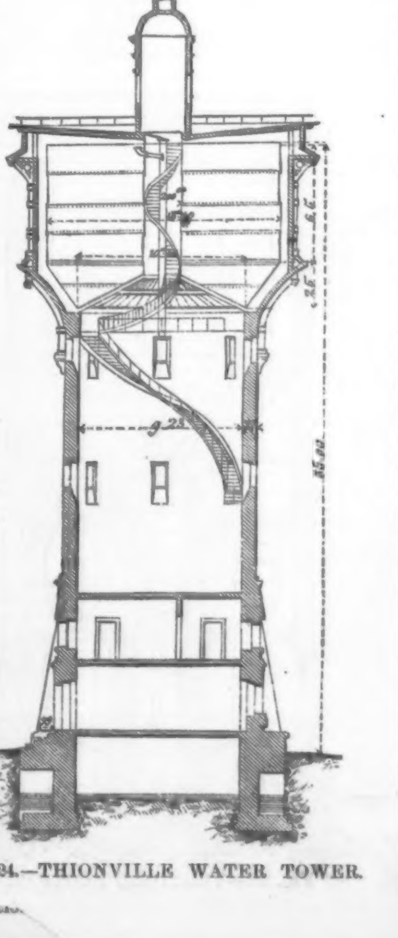


FIG. 24.—THIONVILLE WATER TOWER.

the supporting ring. The conical form, then, it would seem, should be rejected. But it is not indispensable, *a priori*, to place the annular support under the arris that externally limits the conical bottom; it can be placed above. In such a case, we shall have on the one hand a suspended internal bottom in which the plates are under tension, and which will be calculated as above, and, on the other hand, a supported external bottom in which the plates operate by compression in the direction of the generatrices and by extension in that of the parallels.

Referring to Figs. 11 and 12, and designating by G the weight of water to the apex of the cone, whether the latter exist or not, we may determine by the process that has given us the values s and t (equations [1] and

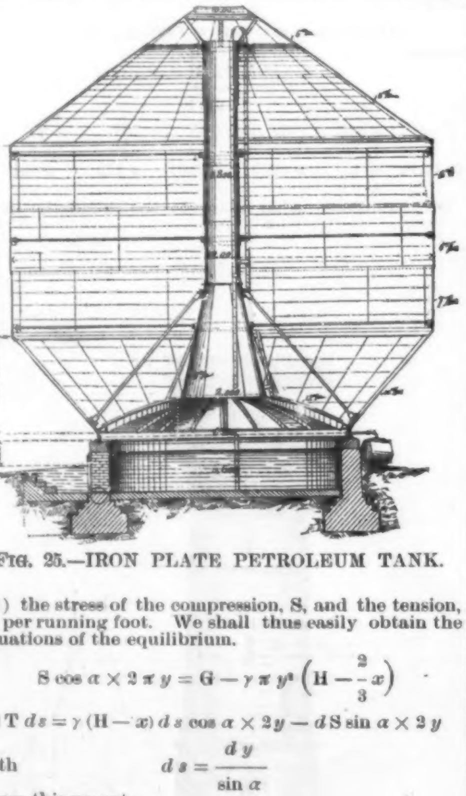


FIG. 25.—IRON PLATE PETROLEUM TANK.

[2]) the stress of the compression, S, and the tension, T, per running foot. We shall thus easily obtain the equations of the equilibrium.

$$S \cos \alpha \times 2 \pi y = G - \gamma \pi y^2 \left(H - \frac{2}{3} x\right)$$

$$2 T\, ds = \gamma (H - x)\, ds \cos \alpha \times 2 y - d S \sin \alpha \times 2 y$$

with $$ds = \frac{dy}{\sin \alpha}$$

From this we get:

$$S = \frac{G}{2 \pi y \cos \alpha} - \frac{\gamma y \left(H - \frac{2}{3} x\right)}{2 \cos \alpha} \qquad [11]$$

$$T = \gamma H (\cos \alpha + \tfrac{1}{2} \sin \alpha \operatorname{tg} \alpha) y + G \frac{\operatorname{tg} \alpha \sin \alpha}{2 \pi y} - \gamma \cos \alpha \left(\frac{1}{\operatorname{tg} \alpha} + \tfrac{1}{3}\right) y^2. \qquad [12]$$

These relations will not change if the form of the internal bottom be modified. It will be possible, therefore, to suppress the point of the cone, which only serves to hold a lot of water that is of little use, since it is situated too low down, and to replace it by a cone directed upward. Designating, then, by σ and τ the stresses of compression analogous to the stresses S and T, we shall find for the internal bottom (Fig. 13),

$$\sigma = \gamma \frac{h + \frac{2}{3} x}{2 \sin \beta} y \qquad [13]$$

$$\tau = \gamma \frac{h + x}{\sin \beta} y \qquad [14]$$

τ will be almost double σ, and will alone determine the thickness of the plates. If, instead of a re-entrant conical bottom, we adopt a spherical dome-shaped one (Fig. 14), the preceding equations will become

$$\sigma = \gamma \left(h + \frac{x}{2}\right) \frac{r}{2} \qquad [15]$$

$$\tau = \gamma [h + x] r - \sigma \qquad [16]$$

While the external conical bottom tends to compress

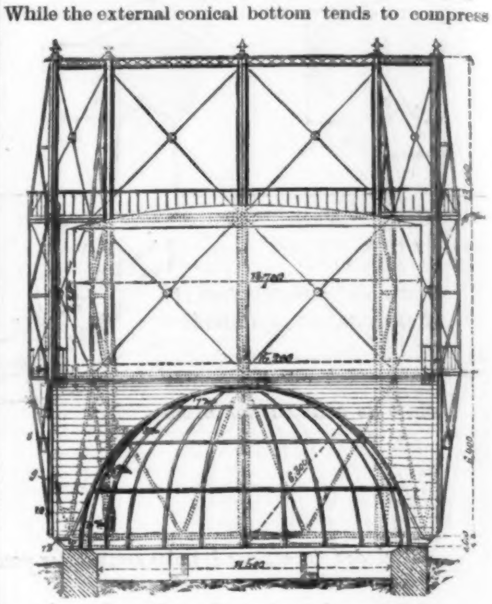


FIG. 26.—IRON PLATE GASOMETER.

the annular support, the internal one tends to distend it. Profit may be taken of this to balance these two actions by making

$$S \sin \alpha = \cos \beta;$$

whence, $$\cos \beta = \frac{S}{\sigma} \sin \alpha.$$

We thus manage to greatly relieve the annular support.

When the internal bottom is wider, as in the case of large reservoirs, the cone occupies too much space, and uselessly lessens the tank's capacity. In this case the top of the cone is made concave (Fig. 16). This in nowise changes the stresses that occur upon the annular support, and this part will have less surface and a slighter tension, especially if a small radius of curvature be given it. The connection with the conical part is effected by a simple angle iron.

A spiral staircase is often constructed in the middle of large reservoirs. It will prove advantageous, when the dimensions of the tower are large enough, to adopt the arrangement shown in Fig. 17. The internal cone is replaced by a series of irons bearing at once against the annular support and the cylindrical shell of the staircase, and supporting plates that are strongly curved toward the base. These plates must be of slight thickness.

We have now seen what advantages are possessed by various forms of bottoms, and how the thickness of the plates is calculated in one definite form. This would not suffice in the construction of a water tower, since, if some form be adopted in a general way, it will be necessary to establish the ratio between the height and diameter, as that has a notable influence upon the cost price. It will therefore be necessary, for the various values of one such dimension considered as variable, to calculate the cost of the various parts (masonry, wall, and bottom), and to add to the sum the capitalized cost of making. This done, we lay off the variable dimension in abscisses, and the total cost in ordinates, and, passing a curve through all these points, at once find the most advantageous dimension—that which corresponds to the lowest part of the curve.

Fig. 18 gives a graphic curve of this kind for two forms, established for a projected reservoir of 19,000 cubic feet at the Neu-Stassfurt salt works. For greater clearness, the forms corresponding to the determinate points are here represented in a summary way. We here clearly see the advantage of the external, conical bottom, with re-entrant cone, over the ordinary spherical bottom. The same result was obtained for a ten thousand cubic foot reservoir for the Rhenish railways, the cost being found to be $3,400 for the conical bottom tank, and $4,200 for the ordinary bottomed one.

As examples of reservoirs projected by Mr. Intze, we give (Figs. 21 and 22) the water tower of the city of Remscheid; the Szegedin reservoir (Fig. 23); the Thionville double reservoir (Fig. 24); and the Duren reservoir (Figs. 19 and 20), which has a capacity of 35,000 cubic feet, and the level of the water in which is 150 feet above the ground.

Apropos of this latter, we may point out an architectural advantage in favor of the Intze system. Had in this case an ordinary reservoir been adopted, it would have had the form of a cylinder 150 feet in height, the reservoir having the height of the tower. In order to conceal what there is of monotonous and ugly in such a structure, it would have been necessary

to have recourse to all sorts of artifices, such as giving relief by means of an enormous projecting cornice, by pilasters, and a kiosk over the staircase, etc. All this would have cost money, and the final effect would have been paltry at the best. An inspection of Fig. 20 will show that the Intze system, on the contrary, thanks to the projection of the tank beyond the tower, lends itself with the greatest facility to architectural decoration.

Fig. 25 represents a petroleum reservoir constructed by Mr. Intze for a well near Theissen. This reservoir holds 16,500 cubic feet of oil rich in gas. The form adopted is the most advantageous one for an entirely closed reservoir, since it answers to a minimum of surface. There is a project afoot to construct five more of these reservoirs of the same capacity.

Where the ground is bad and is incapable of supporting much of a load, it becomes very difficult and expensive to construct a masonry gasometer, since it requires the entire surface occupied to be covered with piles. In such cases it would prove advantageous to adopt an iron plate gasometer. It would be only necessary to drive down a ring of piles, and build a low wall upon these, and place the tank upon it. A gasometer on this plan has been constructed at Emmerich, and another one at Wurzen. This last is shown in Fig. 26. In this kind of reservoirs the bottom should be raised very high, and be made to occupy as much space as possible, so as to diminish the weight of the contents, and permit of access beneath for stopping leaks, etc.—*Le Genie Civil.*

[Continued from SUPPLEMENT, No. 555, page 8863.]

SIBLEY COLLEGE LECTURES.—XI.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

THE "LABOR PROBLEM."

WITH A DISCUSSION BY PRESIDENT ADAMS AND OTHERS.

Second Session.

PROFESSOR THURSTON: In continuing the debate which has proved so interesting and so instructive, it is our good fortune to be permitted to listen to an expression of views of another member of the Faculty of the University, whose studies in history and political economy have often led him over the ground which we are now traversing, and whose well-known accuracy in matters of fact and logical methods of thought make him an authority, and an accepted one, in matters of social and political economy. It will be a pleasure to all, I am sure, to hear what Professor Tuttle may be inclined to say on this subject.

Professor TUTTLE said, in substance, that one of the things which disqualified him for discussing the labor problem was his skepticism about the existence of any labor problem of the unusual and momentous character which many persons profess to see. That was to say, the questions underlying the present troubles were not essentially different from those which had appeared in other ages of civilized society. The relation between half a dozen workingmen and their employer, or between a thousand workingmen and a group of employers, was always, and naturally to a certain extent, one of rival forces. The workingmen desired to get the highest possible price for their labor. The employer desired to get labor at the lowest possible rate. This was a simple statement of the labor problem as it had existed in all ages; and while the greater complexity of modern social institutions, the more rapid means of communication, the greater facilities for exchanging information, the superior intelligence of workingmen, and the greater concentration of both labor and capital, these and other circumstances, made the problem to-day perhaps more intricate, he could not see that it was essentially different from the problem of former ages, or called for any radically different solution. Some of the schemes which had been proposed amounted to the fundamental reorganization of society. He had little faith in such measures. Although he was still a young man, he had passed through many isms of that kind. There was a time when he had thought that he could reconstruct society on a basis far broader and more equitable than anything the world had ever seen, but the older he grew the more he became convinced that social institutions would remain in the future what they had been in the past, subject of course to the natural laws of organic progress and development. No arbitrary legislation could all at once essentially change the structure of society. Important reforms could and would be made in laws and government, and these would benefit workingmen more than all fanciful schemes for a social revolution. He had been much struck by the moderate and reasonable tone of Mr. Bayles' addresses. With much that that gentleman had said he heartily agreed. Even the proposition that the wages of labor should bear some relation to the prosperity of the employer was unobjectionable, so long as it was voluntarily accepted by both parties. He could not, indeed, see that the assertion that wages were paid from profits, and not from capital, was of much practical value. The more the employer paid out of his profits for work, the smaller the balance remaining to be added to his stock in trade, so that wages might be said to come out of eventual, if not out of original, capital. But he would not insist on that. The more important questions which would suggest themselves to everybody were, What share of the profits ought to go to the laborers? Who would fix the ratio in case of disagreement? Who would enforce the ratio in case the employer refused? Evidently, no power could do this, except a power above both the parties, and armed with coercive authority. But this could only be the state, and such a function went, in his opinion, beyond the legitimate duties of the state. The state was within its proper sphere only so long as it confined itself to enacting and enforcing just and equal laws, and securing that social order which enabled labor and capital, under free competition, to obtain the fullest and fairest development. Referring to the Southwestern strikes, he said they had thrown a flood of light upon the purposes of some of the labor agitations. From their standpoint, he thought a word could be said in defense of Martin Irons. Irons seemed to him the only logical and consistent person in the whole business, for he had adhered throughout to the end which the strikes originally had in view, that is, the vindication of the power of the Knights of Labor as an organization. To do this, it was better not to have a concrete grievance, for victory in that case would be regarded as a triumph of justice, and not of power. It was thus a sign of weakness, and even defeat, when in the Southwest, as on the Third Avenue railroad, the strikers began as a second thought to collect evidence of tangible abuses. It gave away the original object of the movement. But in a strike merely to assert their power, the labor organizations would never command the sympathy of the American people. That was not the method of the English race in any part of the world. They would fight hard against an actual evil, but they never had fought, and never would fight, to establish an abstract theoretical proposition. Nor would they sympathize with a struggle conducted on any such basis, with strikes precipitated upon the country without just cause, and for no apparent reason, unless it were they might afford occupation to Mr. Powderly, Martin Irons, O'Donnell, and the rest, and thus keep up the flow of contributions from their deluded victims.

In regard to labor organizations in general, they were, of course, unassailable so long as they kept within the law, and in some cases they might render real service. But he was in doubt whether, as now conducted, they would not prove an evil rather than a benefit. For one thing, they must have a tendency to lower the quality of service performed, when they make it a part of their mission to prevent the discharge of poor workmen, and thus incidentally to prevent the recognition of superior merit, and to discourage individual zeal and ambition. Again, their spirit favored the perpetuation of class distinctions. If the workingmen were to be knit together in ironbound leagues, which claimed all their attention and loyalty, the effect would be to suppress individualism, to develop an exclusive class feeling, and lessen the rapidity of that movement which in this country has constantly re-enforced the ranks of capitalists from the laborers themselves. But this subject was a vast one, and he could only throw out these suggestions for reflection. In conclusion, he warned again against encouraging workingmen by delusive and impossible schemes. With every proper attempt to improve their lot, the people of this country would heartily sympathize; but only mischief would be done by holding out to them the hope that society was to be or could be radically changed in such a way as to reverse their relations to the labor-employing capital of the country.

Professor THURSTON: The discussion of the labor question has, so far, been conducted from a single point of view. The subject comprehends the relations of two great classes to each other—the capitalist and the employer of labor on the one hand and the workingman, the employe, on the other. It is somewhat important to a correct settlement of the question that we obtain the views of the first class as expressed by some one who can fairly represent that class, by a man who wields large capital, who is accustomed to employ large bodies of laboring men, and who is known to be a man of large experience, of good judgment, of kind heart, and fair in mind. We hear much said in behalf of the laborer; it is not often our privilege to hear what those whom he is too often disposed to regard as his natural enemies would say in his behalf as well as in their own. It is not impossible that a man of the capitalist class, who is a good man and a good citizen, whose earnestness and honesty of purpose, whose wisdom and integrity, are known to us all, may be able to present views that may awaken new thoughts in our own minds, and give us an insight into the question that we should never obtain except by listening to him. We are fortunate in having with us to-day a gentleman to whom we shall all feel it a privilege to listen, and who is competent, if any man in the country is competent, to throw light upon the matter now occupying us, from the standpoint of the employer of capital and the director of labor. I have not inquired whether he is prepared to address us to-day, but I will take the liberty of calling upon Mr. Henry W. Sage, of Ithaca, for an expression of his ideas of the "labor problem."

MR. SAGE: I have listened with much interest to the discussions upon the labor problems now before us, but I do not wholly agree with those who have preceded me as to methods of solution, nor as to the soundness of their premises.

I deny that there is any justly called conflict between capital and labor. I deny that capital is or has been in any broad sense aggressive toward labor, and that labor has in this country any just grievance. If there be an occasional exception to this rule, it is isolated, and does not affect the general fact. There is not to-day, there never has been in this world, a country where the wages of labor are so high as they are here. If during our war they were nominally higher in currency, the highest wages then would purchase less of needful subsistence than the wages paid now. Then why this outcry against capital and its owners? Whence comes it? It is not mainly from Americans, but mostly from our foreign population, from countries where they never earned a third the wages they can earn here; who had, it may be, a real grievance at home, but whose idea of liberty here, where they have none, is to take by combination, by force, and by intimidation the money earned by others, without giving an equivalent. In the language of one of their leaders, they neither "believe in God nor government." The present excitement is born of the basilar elements of man, is a greedy, unjust, uncalled-for attack upon the business interests of this country and the property earned and owned by the managers of its great industrial interests.

There is no danger here that the men who organize our great enterprises of commerce, manufactures, or transportation will deal unjustly with the laborers who are their instruments and helpers. They have not done so; on the contrary, all the great organizations of capital and able men for such enterprises have been beneficent to labor—increasing vastly its area and uses, and increasing the wages paid for it. They have paid labor its full value to them, and all they can afford to, the proof of which is that nowhere are wages so high as here, nowhere do laborers have so many comforts as here.

It is a libel and a slander upon the leading organizers of great industries here to charge that they are the oppressors of labor. They are not. As a class they are broad, liberal, intelligent, and doing more to-day to promote the real interests of labor—to promote education, morality, and religion—than any other class in the land. Nothing could be more unjust, more lacking in truth, than the charge that they oppress the laboring man, or desire to.

The difficulty is not there; it is in the moral quality of that class of laborers who forget that with prudence, economy, and self-denial, such as our forefathers cheerfully practiced, and such as most of the wealthy men of to-day once practiced, any man may in a few years lay some foundation for a comfortable competency. Without the exercise of these qualities, most men will fail to do so, and ought to. The world owes no man a living unless he squarely earns it. Let this be remembered. The farmer cannot have corn without plowing and planting, gathering and saving. The remedy for present evils is not in combinations to force from capital already earned, and possessed by somebody, an unjust demand for more wages—that is the freebooter's method; not by co-operative partnerships, not by schemes of social reformers, who assume that they can manage the affairs of all mankind with more wisdom than they have yet acquired, each acting for himself under the pressure of his own interests. The world is not ready yet to accept or even to try the methods of these self-appointed reformers. The remedy is in the moral elevation of men to the point where they are willing to do justly, to perform their contracts, to be true to all their obligations; to be industrious, prudent, saving; to practice self-denial when need be while laying foundations for future wealth and comfort; and to be contented and manly in the sphere wherein God has placed them. These qualities in the laborer, and on the part of the employer such breadth of justice, wisdom, and kindness as we may reasonably expect, will best serve to build up the great industrial interests of this country, and will always insure the rights of both by wise and peaceable methods. Until this moral condition is reached, there is but one other remedy by which turbulence and anarchy, such as now exist in portions of our country, can be suppressed. That is in these three words—"*Enforce the laws!*"

Professor THURSTON: It would be impossible to obtain a better exposition of the subject from that point of view than has been given us by the last speaker; but we cannot have too many lights thrown upon so important a subject, and it will interest us all to hear what is thought of it by another gentleman, who, I see, has attended very closely to the discussion now approaching its termination, and who is likely to have some views formed in the course of a long experience in that pursuit which underlies all others, the foundation of all the arts, the art of agriculture. It will give us all great pleasure to hear what Professor Roberts may be willing to offer us, speaking, as he himself says, "from the end of the hoe-handle." I have now the privilege of introducing the Professor of Agriculture of Cornell University, Mr. Roberts.

Professor ROBERTS: Since more than 75 per cent. of all the people in the United States are so poor when they attain majority that they are compelled to put forth immediate effort of both brain and hand—and that it is so is the salvation of a great republic—labor will always be in excess of capital, according to the laws of supply and demand.

We can only solve the problem, therefore, by increasing capital with which to employ labor or by decreasing the supply of labor.

"He that will not plow by reason of the cold, therefore shall he beg in harvest and have nothing," I interpret to mean that if he who in youth will not sacrifice present ease and comfort, nay suffer, and that severely, will beg in harvest, may we not expect that by autumn he will end in the poorhouse?

The young man that receives from two to three dollars a day may, by strict economy and frugality, save one-third of his earnings, and as early as middle life become independent of the capitalist and employer, thereby unifying the interests of labor and capital. In any ordinary American town more money goes over the counter of the saloon-keeper and the tobacconist than to pay the butcher and the baker.

The few, only, make money very rapidly; the millions must be plodders, and become capitalists by saving rather than by making money. As there is no royal road to knowledge, so in this country there is none to wealth. By the hardest toil and strictest economy of time, the studious boy becomes the eminent scholar, and reaps abundant harvest; so, by the hardest toil and strictest economy, the poor boy may become the capitalist.

Legislation can make neither the one nor the other; it can only smooth down some of the rough places. A previous speaker has said that fifty years ago the laborer owned his own house, his tools, and the material he worked upon; to-day, a laborer may, and often does, own his house, and, what is equally as well, tens of thousands have bank accounts, and have infinitely more of the comforts and pleasures of life.

A few workmen in large cities and in a few establishments are oppressed, and legislation can and should do much to relieve them; but in ninety-nine cases out of a hundred, they are free to sell their labor and their money to the highest bidder.

Finally, I find no limit to divide the laboring from the leisure class; is it between the pen and the paint brush, the brush or the trowel, the trowel or the sledge hammer? Thank heaven! in America we have no leisure class, properly speaking; the man who stands highest socially is frequently the one most overworked. I know of no other or better way to lay the foundations of knowledge, wealth, and honor than by the most economical, laborious, painstaking toil. The prizes that require no effort produce no development of manhood, and are worth little or nothing when possessed.

Professor THURSTON: The time for closing this very interesting, suggestive, and instructive discussion has arrived. Not that more time might not be profitably given to it, or that the subject is nearly exhausted; we have hardly more than scratched the surface of one of the most fruitful and "paying" fields of thought that statesmen or philosophers, business men or scholars, have ever attempted to till; but that we have come to the end of our list of instructors. It becomes my somewhat responsible but very pleasant duty, before clos-

ing the discussion, to thank our friends for their kindness in taking so much trouble to lay before us their views of the great question now agitating every thinking citizen of our country, and probably of the world.

I am asked to give an outline of the train of thought awakened in my own mind during the progress of the discussion which I am now to close; but I have collected so long a memorandum of comments, and such an intimidating mass of notes, that I fear that I shall weary, rather than interest, an audience already fatigued by the effort of following so long and so thoughtful and thought-compelling a debate. I hope, however, that those who may find the session overtaxing and wearisome will not hesitate a moment to pass out by the open door.

"The labor problem"—the term is becoming rapidly hackneyed, but I know of none more expressive of the idea involved—is not, I think, really a problem relating, primarily or principally, to hours of work or to the amount of wages paid for the results of a certain amount of applied labor, but it is, as it seems to me, the problem how best, how most promptly and practically, to satisfy the perfectly legitimate and perfectly commendable aspirations of honest men struggling under sadly discouraging circumstances to gain better things for themselves and their dependants. The labor problem is the problem of all ages, the problem sought to be solved by the greatest and best men of every race and of every country, from the earliest times of which we have record; and probably long before. Those aspirations are noble and generous, and worthy of all honor. It is the duty of every man and woman, of all good citizens, to give to it earnest, honest thought, to seek its solution as they would seek the welfare of all who are nearest and dearest to them; for it does indeed affect every man, woman, and child; every father, every mother, every son, and every daughter; high or low, rich or poor. In this world, there is none independent of his neighbor's weal. Rich and poor are mutually dependent, and the welfare of the one class is dependent upon, and fluctuates with, the fortunes of the other. This struggle for a solution, forced or spontaneous, of the great problem of all times, which is to-day simply more plainly in view than formerly, is not a struggle for more dollars for the workingman, but for all the good things that dollars will bring; for all that is needed by the mind and the soul of man, and of which poverty deprives us; for all the necessities of growing intelligences, as well as of human bodies; for all the comforts of life; for all those healthful and desirable luxuries that every individual, of whatever class, has a right to aspire to possess.

This question is not how to secure shorter hours of work for the worker, but rather how to obtain more time for rest, for recreation (for *re-creation*), for self-improvement, time to help the overworked and worn-down wife, to lead the unguarded and uncontrolled children toward the right, time for thought, for study, for growth, and means of securing progress beyond the present life of treadmill drudgery. It has been said that the strifes and the heart-burnings of troubled times like these have no basis in reason. In one sense it is true; but, in another sense, it is, I think, not so. There may not be a reason; but there certainly is a cause, as there is a cause for every phenomenon, whether occurring in the intellectual, the moral, the social, or the material world. That cause is, as has just been said, the desire of all humanity for better things, for continual progress. Every one desires, and every one needs, daily, more than the day gives; and this is simply the expression of a feeling implanted in every bosom; and this feeling, this desire, is right. No man may rightfully condemn it; every man should seek to do what he may to gratify it, in every legal and proper way.

The evident fact is that the world is daily and rapidly growing richer in all that makes true wealth; and all mankind rightfully aspires to gain the most possible of that wealth, and of all that its possession gives, whether of material things, of power, or of what gratifies the heart, the soul, the intellect, the senses. The progress of the world is continually onward, and the great mass of mankind is constantly gaining as it advances.

Pessimists say that the rich are growing richer and the poor poorer, as a consequence of this progress; optimists are saying that the poor are gaining more rapidly than the rich, as a class; while statisticians show that, in a sense, both have ground for their beliefs, although the statisticians seem mainly to uphold the brighter view. But this does not concern us just now; the fact of importance being that the great masses of mankind are neither as well supplied with the necessaries of life—which include rest, leisure, time for recreation—nor with comforts, to say nothing of the luxuries, as they have a perfect right to aspire to gain. But, whatever the legitimate aspirations of humanity, whatever the moral rights of any class, those aspirations and those rights must be subject to the laws which govern the world and the race. We can never hope to successfully struggle against the laws of nature. We must be content to take what we can get, through the operation of those laws, and must seek our objects through the action of natural law, and not by its overthrow. We are in a steadily flowing stream, and cannot ever hope to make progress against the current. But, fortunately for us all, this stream is an upward-flowing one; we may sink in it, or we may float. If we can keep our heads above water, we shall always rise with the tide. National progress is upward and onward; individual progress is determined by the natural powers and the actions and deserts of the individual.

It has been said that, while the efficiency of labor has increased five hundred per cent., the rise in wages has been but one hundred. True! But this means that the wealth of the world has increased its rate of accumulation, not merely by the increased efficiency of labor, but also by the increased productiveness of natural powers, harnessed by the mechanic and inventor to his machinery. It is really the efficiency of mind, not muscle, that has been so enormously increased. It is to be remembered, also, that, while the wage of the worker has been increased 100 per cent., the wage of capital—the interest received for the use of accumulated wealth and money—has actually decreased enormously. Money, on absolutely safe "security," is to-day worth less than three per cent. It is the risks of business that make mortgages bring six, manufacturing stocks par at eight to ten per cent., and mining stocks at twenty. The capitalist has suffered in by far the higher proportion; and any honest man can raise money on the strength of a good record, of good character, or on good security of whatever kind, at half the rate that was demanded of his father a generation ago. Farm mortgages in the West, where, a few years ago, money commanded eight, nine, and ten per cent., are now negotiated at six, with a prospect that it will soon be difficult to secure that for the mortgage on "first-class security," so called. Capital is thus becoming more and more available to the poor who must borrow, and who have the security of good record and good character to offer. Capital seems likely ultimately to become of almost no value, practically, as gauged by its earning power when loaned; labor, skilled labor particularly, is becoming more valuable, as gauged by its power of earning, or creating, continually. It is continually gaining in power of acquiring, by exchange, the essentials to comfortable life.

Capital and labor, the capitalist and the worker for wages, are alike subject to nature's laws, to God's laws. Growth in prosperity, in wealth, in content, and in happiness can only come of most perfect accord with those laws. Those who struggle hardest against them always suffer the most; those who contentedly and quietly follow the well-known methods which have always led to success, methods dictated by the principles taught to every boy who has an intelligent, honest, earnest, thoughtful, and conscientious father or mother, suffer least, and succeed oftenest. It is intelligence, industry, thrift, integrity, prudent foresight, that make the successful man, all the world over; it is lack of foresight, of industrious habits, of frugality and economy, of character, mental and moral, that determines failure, and misery, and discontent without reason. There are exceptions to the rule; but the rule holds good, nevertheless. It is for us to seek the cause of the exception, and to endeavor to remove it.

One of the great laws of social economy governing the whole race is that pronounced centuries ago. "In the sweat of thy face shalt thou eat bread, until thou return unto the ground." And the whole race either gains its bread by the sweat of the face, or, idle, it starves. Of all the laborers in the world, it is the rule that he who gains most gains it by greatest effort. As a rule, the man who has accumulated property is he who worked while his neighbor slept, and planned and looked forward while his brother sought his pleasure or his rest. Look about among your wealthy acquaintances, and see if you find one who, beginning where such men invariably begin, at the foot of the ladder, did not make his fortune by most extraordinary energy, prolonged and exhausting toil, and exceptional wisdom and strength of character. Occasionally, but very rarely, such a "success" is attained by wrong methods; but the man who so gains wealth finds his prize the "apple of Sodom," turning to ashes in his mouth. No one of us can envy him.

Another of the laws governing the world of industry is that which adapts the supply to the demand. The instant the quantity of any material or product offered in the market exceeds the demand at the ruling price, at that instant the price must fall or the sale must be checked; the sale being checked, manufacture must be checked; men must work shorter hours, or some must be thrown out of employment. Could the supply of every marketable product be precisely adjusted to the demands of the market, the business of manufacture and sale would go on uninteruptedly and smoothly; if the supply and the demand fluctuate seriously, and without adjustment, each to the other, the course of that industry must be correspondingly variable and unsatisfactory. This great foundation law of industry and trade can never be evaded or annulled. It controls the whole industrial world as certainly as does the force of gravitation the material world. Temporary apparent evasion is but the damming of a stream, which, seeming for the moment to cease flowing, sooner or later breaks over the barrier, and sweeps along its channel with an energy which is the more resistless and the more destructive, the longer the period of retardation.

The work of the nation is measured by the necessities and the wants of the nation. In order that the nation may have work, and sufficient work to win for itself bread, clothing, and a roof, education, and a competence, each of its citizens must produce his share to need such a demand for food, clothing, and other necessities and wants as will furnish employment to the workers of the nation. The wants of the nation measure the demand in its markets for all marketable products, and measure the amount of work which can be offered to workers. In order that these wants may be supplied, they must first be caused to exist; that is to say, the nation must have attained such a position, to such civilization, as will cause its people to have wants; these wants will be proportional to the intelligence and civilization of the country. In order that these wants may be met, the country must have a *system* of industries, and a *system* of organization and administration of industries, such as will permit the production of all that is demanded by the nation, will cause the production to be very exactly adjusted to the demand, and will cause the transfer and exchange of commodities so produced to be made possible at the lowest possible cost to the nation. The higher the civilization, and the wealthier the people, and the greater the number of liberally spending rich citizens, the better the organization of the system of production, of transportation and exchange, the greater the variety of the nation's wants, and the more diversified, consequently, its industries, the greater and the more various the work offered to its people, the less the competition for any one kind of work, and the more comfortable and the happier, so far as material wants can affect them, the whole population.

The production of a new article, the opening of a new trade for its manufacture, relieves an overcrowded trade producing an older form of product, and gives the whole body better fortune. It is thus that wealthy citizens, by stimulating production in new lines of industry, most effectively benefit the communities in which they live.

In that organization of industries which must always be effected in order that production on a large scale, to meet a demand of great extent, may be made satisfactory, it is evidently important that we must have leaders, directors, "captains of industry," as well as workers in the lower ranks. As, in a great army, there must be a captain over every company; there must be colonels where there are companies acting together as in a regiment; there must be generals where regiments must be handled in numbers, forming an army. As in the army, there are men, many men, fitted to command a company, to be "foremen" in the shops. There are a smaller number of men capable of directing establishments, of commanding a regiment, and fewer still competent to direct an army, whether military or industrial. General Grant, in his memoirs, occasionally gives his opinion of officers who served with him during the civil war. He often finds a man who could command a company. He less frequently finds a good commander of a regiment. He only once or twice tells us of a man of such superlative standing among his fellows that he would be intrusted with the direction of an army; and we all know that, in the whole four years of strife, there was but one man who proved himself to possess every requisite demanded of the commander in chief of all the armies of the United States—and that man was Grant himself. So it is in the industrial army. Men must take their places there according to their powers of achievement and their merits. The great man will gravitate upward, the weak and incompetent men will gravitate downward, each toward his proper place; and each man, doing his best, must take the place assigned him by the talents, strength, and character that may be his; and it is right that he should. The leaders are always the strong, brave, far-seeing, wise, and prudent, the enterprising and energetic; they are evolved from the great mass of humanity, and sent to the places which their deserts have won for them, places won by hard work of hand and brain. Such men are the leaders in every community, and generally, the larger the community, the greater their number, and the greater the men. The weak, the incompetent, the sick, and invalid, and otherwise unfortunate, drift downward, but rarely fall out of sight, or fail of care from the more fortunate and successful. The average man does the average work of the world; and there are a hundred of this class, to one fit to direct ever so small a body; there are a thousand, to one competent to manage an establishment; there are ten thousand, where there is one equal to the management of a large business.

In the administration of the great industrial system arising in every civilized country, as a necessary means of procuring the products of industry demanded of the people of that country, well established and well known business principles must be adhered to, or the administration will be unsuccessful; the business be a failure, the production must cease, the capitalist will lose his money, and the workers must suffer, and perhaps starve. These business principles are simple, easily understood, and are well recognized by every intelligent business man and probably by every intelligent workingman in the country. Business can only be successful and profitable, and can only be expected to be stable and permanently safe, when, in the first place, enough capital can be collected together to insure it against interruption by any exceptional accumulation of liabilities, in its legitimate operation, requiring to be paid at one time. Business can only be safely undertaken when the necessary amount of materials, the needed machinery and tools, and the other miscellaneous portions of its plant and outfit, can be brought together at the same time with the collection of the required working capital; it can only succeed when the total cost of production, including interest, depreciation, and wear and tear and repair accounts, as well as cost of labor and materials, shall be less, on the average, year in and year out, than the amount obtainable in the market, reduced by the cost of making sales, and so much less that the full market value of labor and of capital used in the business can be paid for their use. It is only when this amount is exceeded that there is a manufacturer's profit in the business, and that it becomes safe to carry it on.

But it will be asked: What is capital? What are wages? Capital is accumulated "energy," as the mathematician or the engineer would say. It has been accumulated by the possessor, by the expenditure of extraordinary energy, industry, skill, or intelligence—usually all these qualities—operating through years of steady, unflagging devotion to business; it is like the energy accumulated in the flywheel, which is drawn upon at intervals to supply power to which the machine, in its normal condition, is unequal; or it is like the store of water in the reservoir above the mill-dam, capable of giving out power to drive the mill in time of failure of the regular flow of the stream, or like the energy pent up in the reservoirs of a compressed air engine, stored there for use as demanded by the machine. Capital always represents the stored product of work done, at an earlier period, by men who worked sufficiently hard, and with sufficient intelligence, to secure a surplus above the necessities of the moment; often this surplus—generally, I presume—is accumulated, in part at least, by the most self-denying and most frugal of lives, father, mother, children, all saving to-day that capital may be accumulated for to-morrow. Capital may take any or all of a thousand forms; but it is always stored power, and has an equivalent in a certain sum of money, by which it is our custom to measure it. Money and capital are alike stores of energy, available for all the industrial purposes of the world; they are mutually interconvertible, and always have a "definite quantivalence." In business, the capital is put in, in the form of buildings, tools, the material to be worked into the finished product, and a certain amount of working capital, in the form of either money or assured ability to procure money as needed, which assurance is called "credit."

The capital being obtained and invested in "plant" and material, the next requirement is the labor needed to convert the raw material into the desired product, that is to say, a certain amount of "energy," or working power; for energy is needed to produce any and all of the changes which are the result of effort and work. Of this labor, or expenditure of power and energy, a part is supplied by natural forces, as by the heat and chemical energy stored in coal, the mechanical energy of the waterfall, and a part is supplied by human hands. Intelligence is also needed to direct the operation both of the inanimate and the animate forces to be set at work in the business; this is furnished by men employed to use the brain, as the laborer is employed to use the hands. The inanimate power

is supplied by capital; the animate power and the brain are supplied by paying, to those who desire and are able to furnish them, an equivalent, in the form known as "wages," paid from the supply of working capital. The worker receives the exact value and equivalent of his labor when this capital, so paid him, measures the exact value of his producing power to the nation. If he is given more, the whole nation is defrauded; if less, his family are defrauded, and his own future, by so much as is represented by the value which that difference would give it.

Neither the rate of wages nor the rate of interest or value of capital can be determined by the claims, or even by the needs, of the interested "parties" in any healthful business arrangement. The worker may want and may suffer for lack of higher wages than the $2 that is paid him; the capitalist may desire, and may demand, more than the six per cent. which is offered him; but neither the demands of the vendor nor the plans of the purchaser of either labor or of the use of capital can permanently settle what is to be paid. *That* is settled by the laws of trade and of nature. If labor is worth $2 or $10 to the business, and if capital is worth four per cent. or eight, the $2 or the $10, the four or the eight per cent., *must*, on the average, be paid, under the all-compelling law; and neither party to the bargain can secure permanently and safely another rate. The claim of either the wage earner or the capitalist to establish hours of labor, rates of wages, or of interest on capital, are contrary to the laws of the industrial universe, and cannot be permanently enforced. The employer and the employed are subject to the same law, and stand precisely on the same footing, in this matter. If the labor market offers higher wages, it is not because the worker for wages demands it, but because more workers and more labor are needed; and that is the way in which natural law settles the difficulty, by soliciting more work, by offering more for labor. If the returns on capital decrease, as they have decreased now for many years, it is because capital is becoming more plentiful, and nature takes that way of turning productive labor into other more important and useful channels than those which lead to its accumulation. Nature's laws are no respecters of persons or of necessities: the laborer may find it difficult to keep a sick and suffering family from starvation, and the poor widow living on the interest of slowly and painfully accumulated capital may find four per cent. insufficient for her needs; but that will make no difference at all, and the worker and the poor capitalist must alike suffer. It is by such trials as these that nature drives humanity to do its best to escape them, and induces the average man to endeavor to make himself and his family safe against future suffering by accumulating capital. Nature's laws, God's laws, are and always will be pre-eminent.

It has been asserted that the worker, in virtue either of his necessities or of his long service in a business, acquires some "proprietary rights;" but I think it is easily seen that there is here no way in which such proprietorship can be established. No length of service and no amount of desire, no necessities, as President Adams has said, can give to his coachman an *iota* of interest in the business of running that carriage, or in any profits that might be made by keeping it. It is evident, also, that the men who are appointed to direct and control any business must be permitted to have actual and full control, if it is to be successful, just as much as the commander of an army must be allowed full command. Neither laborer in the industrial army nor private in the military establishment can be allowed to dictate to the man appointed, in virtue of his superior abilities, to direct. It is impossible for any length of service, simply, at ruling wages, to give the slightest moral or legal right in the business. The proprietor must be permitted to conduct his business in his own way; for he, alone, is responsible for its success. Those who contribute no capital, and accept no pecuniary risks, cannot rightfully share profits or dictate as to the manner of gaining them. Were any such rights possible, they must be established at the beginning, when the business is established. No man can safely put his capital and his talents into a business, if at some later date it is to be loaded down with unanticipated risks and liabilities. But, as has been seen, no such rights have entered at the start of any business established on the usual form and in the customary way. The full equivalent of the value of labor must be given in wages, and in wages alone.

Arbitration has been suggested, and has been tried, as a means of settlement of disputes arising between the employer and the employe; but it can readily be seen that there is really nothing to arbitrate, in the regular operation of a regular business. Men are employed or discharged as more or fewer are needed, and the rate of wages rises and falls naturally as the demand for labor increases or diminishes. If the employer does not get, as he may think, a fair equivalent for what he pays, he reduces the offered wage, or discharges the workman; if the latter does not get what he believes to be a fair equivalent for what he has to exchange for money, he demands more, and, failing to get it, goes where fair pay is given. If the president and his coachman disagree, the original bargain is dissolved, and they separate, each trying to do better, and each makes a new bargain elsewhere. There is nothing to arbitrate. The men controlling industries must be permitted to "control and operate," "under well defined rules of law" *and* of common sense; for the existing methods of business are founded upon the common sense judgment and the experience of mankind. A claim that the demands, made by one party to a bargain, that a bargain shall be modified, and that the matter shall be submitted to arbitration, is legally and equitably right only when confirmed by the acquiescence of the other side. Arbitration, the parties interested being bound by the decision of the referees, can only be right when originally agreed upon in the making of the bargain. To force one party to submit to the decree of third parties, at the instance of the second party to the bargain, is greater tyranny than that which led to the revolution of 1776. Nevertheless, it is often a happy solution of a serious difficulty wrongly arising, and a properly constituted board of arbitrators is, I am sure, one of the most efficient means possible of securing fair treatment of both sides. It is simply to be remembered that both parties should be heartily in accord in the intention of deciding by arbitrament. Arbitrament almost always means the concession of rights on one side or the other. It is a kindly way of settling difference; it is *not* business. It is very sure to settle by a compromise, not on the line of actual rights. In such cases, the proprietor has much to risk, the employe little; the former must abide by the decision, usually; the latter simply, if not thoroughly honest, walks off if not suited. It is thus evident that the settlement of the wage to be paid should be a matter of regular and thoughtfully considered bargain between the interested parties. "Rights" are not to be secured by violence. It is here that the advantages of organization, not simply to the worker, but also to the employer, come in. It is through this system that trades unions and the Knights of Labor become useful; not by stimulating ill-feeling between the two principalities, not by directing strikes, boycotts, and law-breaking, those curses of the transition state through which we are now passing, but by placing the power of negotiation in the hands of the best and strongest minded men, and thus most promptly and certainly securing the fairest possible settlement of every claim or debated question. Said one of the best business men in the country to me, recently, a man who employs from two to three thousand men, in good times: "If the men would only organize themselves intelligently, and place the direction of their affairs in the hands of their best and most intelligent comrades, it would be a great comfort to their employers, who are now compelled to bargain with the worst, as well as the best, and to deal individually with every man about the place. It would be a good thing for both sides; but as it is, they either do not organize, or, if organized, allow themselves to be officered by the worst characters in the mill." Intelligent workmen are coming to see this, and matters are already improving.

Workingmen's organizations, and organizations of employers—which must necessarily follow—properly conducted, are most promising means of securing the rights of both sides. Workmen must organize to secure the presentation of their case by the best representatives, to help their needy fellows, and to secure the adjustment of the labor market, especially, by sending their surplus and movable labor from the crowded to the uncrowded parts of the labor markets of the country. These are the legitimate objects of organization, and every good citizen will gladly see them attained through the action of the unions. All wages must be paid under a fair and definite bargain, made with the full agreement of both sides. Strikes, lockouts, boycotts, quite as much as all the cowardly and accursed deviltry of dynamite, lie outside the lines of business methods entirely, and should be condemned and put down by every patriotic citizen and honest man, as the most outrageous impositions upon human rights ever yet invented by those whose motto is "What is thine is mine." Young men just going out into the world can take with them no better aspiration than that of opportunity of fighting this modern manifestation of the most abominable form of selfishness, this tyranny of wrong-headed labor over honest and earnest labor. For a strike is not action against an employer; in its final outcome it is an attack upon labor and the laws of nature; it is an attack, on the part of a few laborers defiant of law, upon the great mass of laborers who honor and sustain the law, as does every good citizen throughout the whole country. Such infractions of the law as have recently disgraced our country should be punished, by the law, with the utmost severity. The object and use of law is to insure to every individual in the community the liberty to do right and to secure to each the most absolute certainty of possession of life, freedom in the pursuit, by all proper means, of comfort, happiness, and the widest liberty compatible with the welfare of his neighbors and the community, and to make it absolutely certain that he may hold such possessions as he may have fairly and legally accumulated without molestation. The indictment and prosecution of the men who have broken the law; who have endeavored by violence to deprive their fellow citizens of their legal rights and their property, of their liberty to work when and where their individual interests may lead them; who have seized upon property not their own, and have destroyed the property of other men; who have taken lives, and have, directly or indirectly, in other ways injured peaceable fellow citizens, is a duty both of the community through its public officers and of every member of the community. If, at any time, any one of us finds himself in the presence of threatened law-breaking, such as has lately occurred, the right thing to do is to volunteer as a sheriff's deputy, and assist the officers of the law to uphold it against every outlaw who attempts its overthrow.

It has been said that it is the object of law to attach a duty to every right. I would not say precisely that. The object of law is to uphold the rights of all citizens, irrespective of class; the object of the government is simply to govern. That duties do attach to every right is probably true; but I do not see that we are to predicate moral obligations directly upon legal enactments. The law must be framed upon a knowledge and an acknowledgment of moral and ethical principles universally recognized; and I do not see, for example, that the fact that the law protects property in the hands of its rightful owner, the man who has produced and collected it, gives other men new rights or claims. That the holding of honestly acquired property is an inalienable right seems to me axiomatic; it is denied by some men of socialistic views; but it is only as any other admitted axiom may be denied, by here and there an individual of peculiar mental constitution or of prejudiced mind. The fact asserted by the axiom is the very foundation of all society and of all civilization. Were it not a fact, there could be no civilization, no accumulated wealth of either individual or nation; barbarism would reign supreme. It has been, as I think truly, said that capital should be held to strict account for the results of its operations; it has been said that it has hitherto been uncontrolled; that is, I think, partly true, partly a mistake. Capital has been controlled so far as the necessity and the right to control it by legislation has been made evident. That it still often goes beyond the morally right, while still within the law, is certain; but, with the progress of time, we may expect every serious abuse will be, in some way, abated. To-day the benefits of the law of incorporation are inestimable, not to capital mainly, but to the workingman and to the widow and the fatherless, the seeker for work and those dependent upon small accumulated means; the evils of "soullessness" in corporations are comparatively small, if not really non-existent in the vast majority of cases. To say that a corporation has no soul is to say that its affairs are conducted on strictly business principles; which means most assured prosperity for its business, and that means for all who depend upon steady employment by it for support.

Capital, singularly as it may seem, is actually controlled by labor; it does not "always get the best of the bargain;" it oftener gets the worst of it. A business can only be conducted successfully when the cost of its products is less than its receipts, all expenses of sale being included. Not five per cent. of all men employing labor permanently succeed; ninety-five per cent. of the employers finally come out no better off than the poorest of their employes, after a life of struggle and business worry and strain which few of those who have been given employment by them can realize. Capital is controlled by labor. It must always pay the full value of labor, as regulated by the market; it cannot escape; for the wage-earner is continually forcing the highest prices attainable, and shifting from establishment to establishment, from one part of the country to another, to obtain them, in such a manner as to continually bring every employer in direct competition with every other, throughout the country; and no practicable system of combination by employers can evade either the laws controlling the market or the competition so induced. The employer must also pay the ruling price for capital used in his business—and the number of employers who are not compelled to hire capital, more or less, is very small indeed—and he must keep his buildings and machinery in good condition. If, after he has paid the ruling prices for labor and capital, and has bought his raw material, also at ruling prices beyond his control, in the market, and has set aside the necessary amount of his fund to meet costs of wear and tear and depreciation, he can then secure a margin between total costs of putting his product on the market and the market price of that product, he makes money; otherwise, not. The employer of labor is thus entirely at the mercy of elements over which he has no control; he can only choose, judging from the best evidence that he can collect, whether it is wise for him to go into such a business or, being in, to continue, and he must then take the consequences of his decision. He sometimes acquires riches; but he far oftener meets with utter failure. If he simply obtains a fair interest on the capital invested, he is fortunate; and if he gets, in addition, a fair compensation for the time, thought, and administrative skill which he puts into the business, he is *very* fortunate. In a nation of fifty millions of people, there may be two or three men who attain to marvelous riches; but the number of very rich men in any nation is too small to indicate the existence of a defect in our industrial system, even were it admitted that the possession of the wealth of a Vanderbilt or of an Astor, by a single individual, is, in itself, an evil. The possessor of millions eats no more, drinks no more, is no better clothed or housed, as a rule, than the man who has acquired the competence to which every good citizen aspires; often he is less extravagant in personal habits than the demagogue who inveighs against him. All his vast property is simply so much capital employed in the behalf of workers, supplying work, and supporting families of the poorer men of the land, in all the trades. A millionaire in these days cannot avoid helping his neighbor wage-earners. The more avaricious he is, the more carefully, and, as a rule, the more successfully, does he promote business, giving employment to the most skillful and most industrious, simply to gain for himself more property. It is only by so helping the world about him that he can help himself as he so meanly desires. Later, his accumulations are distributed to the four winds, either by inheritance or by the follies of his heirs. The capitalist is thus seen to be, in spite of himself, a man who affords his fellows most certain and steady employment, and thus, often inadvertently, practices the highest philanthropy; for it is a matter of universal experience that charity is wasted in giving alms to the average poor, and is best bestowed in the form of compensated employment. So, too, the "monopolist" is a man who, however selfishly, does his best for the nation, by leading the way into a new industry, and, by his seemingly easily won success, attracts a thousand other men into the field which is thrown open on the instant of the expiration of his monopoly. The finest illustration of this fact is the operation of our grand system of patent laws. Compare the growth of industries and the accession of inventions in this country with what is seen abroad, and then consider what would have been the fact without our patent laws, which protect every inventor in the introduction of his invention until a sufficient time has been given him to secure the reward of his inventive skill. What if a Singer or a Howe does make his millions? The country gains, and the world gains, many times more than he. Where should we now be without the sewing machine, or the telegraph, the patented devices of the printing press, or the now much and fashionably maligned telephone monopoly? It is the opportunity to gain great rewards that stimulates the inventor to make this the most comfortable and civilized country in the world—outside the range of imported European socialism.

Capital is controlled by labor in another sense; the workers constitute the people of this country. The people have all power; they make effective public sentiment; they make the laws; they make the nation what it is, and determine what it shall be in the future. Is it not perfectly obvious that capital and labor are really mutually dependent, the one on the other, as the brain and the limbs of a healthy body are mutually dependent? Both are in duty bound to "combine;" but they can best combine *together*. Fraternally united, they stand; hostile and divided, they must assuredly fall. Personal and individual freedom exists, under the law, on both sides; but it is a freedom to do right, to help each other, and to work together toward a common prosperity under the operation, always, of the great laws which always have, and always will, control business, to do business in a businesslike way. Both are free to do right, morally and legally right, neither to infringe upon the statute or the moral principles of law. *Absolute* freedom is not permissible or desirable in this world

of ours, so long as the spirit of man is not the spirit of Christ and the angels.

No man is free! The restraints of condition, of family ties and obligations and burdens, are often only overcome by generations of patient toil, of intelligent labor, and most persistent self-denial. The restraints imposed by nature are not easily broken through, and no amount of violence and crime will permanently relieve the race or any individual. The office of the law is to preserve the rights of man under these restraints, not to re-enforce and strengthen them, but to secure all that man can gain in his slow progress toward their abolition in the right and peaceful way in which, only, they can be removed. The law-breaking of "union men" and the law-breaking of anarchists are alike vain and criminal. The accumulation of wealth in the hands of strong, wise, intelligent, enterprising, and energetic men is one of "the ways out." It is only by the gradual organization of all industries in such manner that the men who have been created by nature as captains of industry may command, that the world can be made most prosperous. It is of no consequence who is the legal proprietor of wealth, if only that man is the right man. In fact, the wealthier the better, if the man will but keep his capital well employed. Even the extravagances of the luxurious among the wealthy are of service to the world. The purchaser of pictures and other works of art employs a class of workers who would, necessarily, in the absence of such a means of support, be competing with other workers in more crowded lines of industry. The driver of a rich man's carriage, if not so employed, would be in the labor market, reducing, by just so much, the wages of the man now employed. The purchase of a fine house, a modern Fifth Avenue palace, means the payment of a thousand men for work, which, undone, would leave them competing with the ordinary carpenter, bricklayer, and upholsterer. The more rich men in a community, the better for its poor, all the world over; and yet I would not say that it would not be still better, were it possible, that every man should have a competence, than that one should be rich and another poor. It is simply the fact that, as human nature is to-day constituted, there is, and can possibly be, no equality of natural powers or of fortune. As it is, the rich, however selfish and mean, help the poor, in spite of themselves. Fortunately, though, the inclination to help the unfortunate does exist among the rich, and very much more generally than is commonly believed. All the great philanthropies of the world, nearly, are the fruit of the benevolence of the wealthy; without them, where would we find hospitals, how support our schools, how obtain college education for our young men and young women? The real uses and duty of wealth are, as we have seen, the promotion of industries, the diversification of employments, the erection of great institutions, such as we see here about us to-day. As yet, much remains to be accomplished before the people can be expected to be contented with their lot. The question is, Which is the way out?

There are two ways in which the attempt is being made to find the way out from this slowly breaking cloud, this relic of barbarism, and vastly greater suffering of the distant past. The one, I would call the Devil's way; the other is the way that the spirit of justice and right, the spirit of Christ, would indicate. The way of the anarchists is the one way; the other is the way which has already been pointed out. The first will but lead into deeper gulfs of darkness and misery; the second surely, but very slowly perhaps, always toward the light. In the better and only safe way, we can feel our path surely, and can see it with tolerable clearness. It is easy to lay down the platform of correct principles:

1st. "Enforce the law."

If the peace can but be maintained, the right will come surely and clearly to be seen in good time. It requires but that the people shall have time to think, and to direct action intelligently, and every difficulty will be overcome, and the right will stand up victorious in view of the whole nation. Let no man's rights under the law be imperiled, and the operation of the law will, in time, right all wrongs.

2d. "Give natural law a fair chance to bring about its legitimate results."

Do business in a businesslike way; obey the laws of trade and of nature's own code of ethics. Give every man a fair chance to exhibit his best powers in the best place for their display; allow him to be as industrious as he may choose; let him employ to best advantage all his energy, his activity, his intelligence, and his pluck, in free competition with the world.

Protect every man in the possession of the fruits of his honest industry and of such special talents as he may possess. Make life, personal liberty to do right, and freedom in the pursuit of all proper modes of securing happiness, absolutely secure. Let no man interfere with the personal rights of his neighbor.

3d and finally. "Introduce into life and into every business, so far as is safe and proper, something of personality. Introduce into every action of life the moral law, the golden rule."

Good business habits, doing business in a businesslike way, will lead to the production and accumulation of wealth, and the operation of the human sympathies will teach the best use of that acquired wealth. All the less fortunate of earth have a claim on the more fortunate; but that claim is not a business claim, it is a moral claim, and is recognized by the senses and affections that make man human.

You are going out into a world to do what in you lies. Deal fairly and kindly with all, high and low, rich and poor, bearing and forbearing, and there will come to you very little of the evil of human life. Seek to acquire wealth by every fair and proper means; but when gained, make the most and the best of it. It is a duty to seek to acquire property, but with that duty comes a correlative obligation to so use it that the world shall be the better for your presence in it, both materially and morally. Exercise all through life the great moral rights to do good, to do business by correct business methods, and to do unto your neighbor as you would have your neighbor do to you. Thus will all good come to you in God's best ways. You can then take part in the great work, the two great ways of helping the world, giving work to the worker and help to the helpless.

You can then do most to secure the good things of the world for yourself and for your fellows, material things for the material part, education of the highest and best forms for the intellectual part, humanity for the soul. You, who see about you the results of such grand uses of the good that comes to truly manly men, as illustrated by the monuments rising here to immortalize such men as you may well aspire to follow, need no stronger urging.

TYROTOXICON: ITS PRESENCE IN POISONOUS ICE CREAM; ITS DEVELOPMENT IN MILK; AND ITS PROBABLE RELATION TO CHOLERA INFANTUM AND KINDRED DISEASES.

By VICTOR C. VAUGHAN, M.D., Ph.D., Professor of Physiological Chemistry in the University of Michigan, Member of the State Board of Health.

ABOUT one year ago, and after two years of close investigation, the writer succeeded in isolating from some samples of cheese, which had produced alarming symptoms in many persons, a highly poisonous ptomaine, to which the name tyrotoxicon (cheese poison) was given. The effects of this poison were demonstrated repeatedly upon some of my students, who kindly offered themselves as subjects of experimentation, and upon myself. These were found to agree closely with those observed by the physicians who treated the persons made sick by eating of the cheese. There were reported to the Michigan State Board of Health about 300 cases. The most prominent symptoms were dryness and constriction of the fauces, nausea, retching, vomiting, and purging.

The vomited matter was frothy and the stools watery. In some there was evidence of marked nervous depression. Although in many the condition seemed alarming, all finally recovered.

A report of the discovery of tyrotoxicon in cheese will be found in *Zeitschrift fur physiologische Chemie*, B. x., Heft 2; also in the annual report of the Michigan State Board of Health for the year 1885.

Last November a student brought to me a four ounce bottle partly filled with milk, which had stood tightly closed with a glass stopper for about six months. From this I succeeded in isolating the same poison. It was recognized by its crystalline appearance and by its effect upon myself. It was presumed that this milk was normal in composition when first obtained; but of this we could not be certain.

I then put several gallons of normal milk in perfectly clean bottles with glass stoppers, and allowed these to stand in my work room. From time to time a bottle was opened, and the test for tyrotoxicon was made. These tests were followed by negative results, until about three months after the experiment was begun. I then succeeded in getting the poison from one of the bottles. The method of testing for it was as follows: The coagulated milk was filtered through heavy Swedish filter paper. The filtrate was colorless and decidedly acid in reaction. It was rendered feebly alkaline by the addition of potassium hydrate, then agitated with ether. After separation the ethereal layer was removed with a pipette, allowed to run through a dry filter paper to remove a flocculent, white substance which floated in it, and then allowed to evaporate spontaneously. If necessary, this residue was dissolved in water and again extracted with ether. On the evaporation of the ether, the tyrotoxicon was recognized by its crystalline appearance, by its odor, and by placing a small bit on the tongue. As the ether takes up some water, there is usually enough of the latter left after the spontaneous evaporation of the ether to hold the poison in solution, and in order to obtain the crystals this aqueous solution must be allowed to stand for some hours in vacuo over sulphuric acid.

From one-half gallon of the milk there was obtained quite a concentrated aqueous solution of the poison after the spontaneous evaporation of the ether. Ten drops of this solution placed in the mouth of a small dog, three weeks old, caused, within a few minutes, frothing at the mouth, retching, the vomiting of frothy fluid, muscular spasm over the abdomen, and after some hours, watery stools. The next day the dog seemed to have partially recovered, but was unable to retain any food. This condition continuing for two or three days, the animal was killed with chloroform. No examination of the stomach was made.

It may be remarked here that I have elsewhere pointed out the necessity of using pure ether for these extractions, as some samples of ether contain an irritating, ptomaine-like substance.

June 13, 1886, I received from Dr. Henry B. Baker, secretary of the Michigan State Board of Health, a pint bottle about two-thirds full of melted ice cream, with the request that I analyze it, as some eighteen persons had been seriously affected by eating it. Dr. Baker also sent some of the vanilla which had been used as flavoring. It was thought that the poison would be found in the vanilla, because some lemon ice cream furnished at the same gathering had not affected those who ate it. As the readiest means of deciding this my assistant, Mr. Novie, and myself took at first thirty drops each of the vanilla extract. No ill effects following this, Mr. Novie took two teaspoonfuls more, with no results. This settled the question of the poisonous nature of the vanilla more satisfactorily than could have been done by a chemical analysis.

We then added some distilled water to the cream, and after thorough agitation, filtered it. The filtrate was tested for tyrotoxicon by the method already given. The aqueous solution, after the spontaneous evaporation of the ether, was given to a cat. Within ten minutes the cat began to retch, and soon it vomited. This retching and vomiting continued for two hours, during which time the animal was under observation, and the next morning it was observed that it had passed several watery stools. After this, although the cat could walk about the room, it was unable to retain any food. Several times it was observed to lap a little milk, but on doing so it would immediately begin to retch and vomit. Even cold water produced this effect. This condition continuing, after three days the animal was placed under ether and its abdominal organs examined. We certainly expected to find marked inflammation of the stomach. But we really did find the stomach and small intestines filled with a frothy, serous fluid, such as had formed the vomited matter, and the mucous membrane very white and soft. There was not the slightest redness anywhere. The liver and other abdominal organs seemed to be normal.

It should be remarked that this cat was about two months old. Attention is called to this, because young animals are affected by this poison more readily than older ones. It requires a comparatively large amount of the poison to cause any marked symptoms in an old cat.

After having made these experiments I received from Dr. R. C. Moffit, of Lawton, Mich., the following letter:

"LAWTON, MICH., June 21, 1886.

"DEAR DOCTOR: I understand from Prof. Chas. Lawton, of this place, that the cream sent to Lansing, for examination, has been forwarded to you, so I write to give you the particulars. About two hours after eating the cream every one was taken with severe vomiting, and after from one to six hours later with purging. The vomit was of a soapy character, and the stools watery and frothy. There was some griping of the stomach and abdomen, with severe occipital headache, excruciating backache, and 'bone' pains all over, especially marked in the extremities. The vomiting lasted from two to three hours, then gradually subsided, and everybody felt stretchy, and yawned in spite of all resistance. The throats of all were œdematous. One or two were stupefied; others were cold and experienced some muscular spasms. A numb feeling, with dizziness and momentary loss of consciousness, was complained of by some. Temperature was normal, and pulse from 90 to 120. Tongue, dry and chapped. All were thirsty after the vomiting subsided, and called for cold water, which was allowed in small quantities, with no bad results. After getting out, no one of the victims was able to be in the hot sun for several days, and even yet (about ten days after the poisoning) the heat affects myself. I attended twelve persons, besides being sick myself, and all were affected in pretty much the same way. Several complain yet of inability to retain food on the stomach without distressing them. The man who made the cream took a teaspoonful of it, and he vomited the same as those who ate a whole dish, but not so often nor for so long a time. All are affected with an irresistible desire to sleep, which can scarcely be overcome. Even yet some of us feel that drowsy condition, with occasional occipital headache. Yours fraternally,

R. C. MOFFITT, M.D."

It will be seen from the above that the symptoms produced in the persons agree closely with those observed in the cat. Cases of poisoning from ice cream are by no means rare, and I hope that those who have the opportunity will not fail to test for tyrotoxicon. In the report of the Brooklyn Board of Health for 1885, an instance is given of the poisoning of more than 100 persons from ice cream, sent out from one restaurant. The chemist was unable to detect any mineral poison. The injurious results were attributed to the use of decomposed gelatin; but no gelatin of any kind was used in the Lawton cream. Other cases occurring in New York and Brooklyn have been attributed to the employment of artificially prepared vanilline for flavoring; but the vanilla extract used in the Lawton cream was not poisonous, as has been shown.

As I write this, I notice in the daily papers the report of the fearful poisoning from ice cream, near Lemington, N. J. The papers state that the poisonous substance is arsenic, but how this has been determined is not given. I suppose that arsenic has been named from the symptoms. If it be true that the cream was made from milk brought in by the quart or gallon, by those participating in the festivities, the chance of mixing some milk containing the germ which must produce the poison, with the good, and thus contaminating the whole, was as favorable as it well could be. Of course, if a chemical analysis shows the presence of arsenic, the question is settled; but in all similar instances, chemical analysis has demonstrated the absence of mineral poisons.

The circumstances under which tyrotoxicon develops require farther study. As has been shown above, it may develop in normal milk, kept in a clean bottle for three months; but it is evident that in some instances it appears much earlier. The production of the ptomaine is, in all probability, due either directly or indirectly to the growth of some micro organism. In the cheese Dr. Sternberg found a new micrococcus; but whether or not there is any relation between this organism and the poison remains to be determined. In the cheese, milk, and cream, in all of which I have found the poison, there was present more or less butyric acid, and it may be that there is some intimate relation between butyric acid fermentation and the production of the poison. Some years ago Selmi obtained a ptomaine which resembles coniine, and pointed out that it might be formed by the action of butyric acid on ammonia, thus:

$$\underset{\text{(Buytric acid.)}}{2C_4H_8O_2}+\underset{\text{(Ammonia.)}}{NH_3}-2H_2O=\underset{\text{(Coniine.)}}{C_8H_{15}N}.$$

Or thus:

$$2C_4H_8O_2+NH_3+2H-4H_2O=C_8H_{15}N.$$

In like manner other fatty acids may react with decomposing nitrogenous substances, forming alkaloidal bodies. Tyrotoxicon has no special resemblance, so far as is known, with coniine, but the possibility of these alkaloidal substances being formed in this way is worthy of mention. T. Lauder Brunton, in referring to the writer's discovery of tyrotoxicon, states that from the action of the substance he would infer the presence of two poisons. This is altogether possible. The writer has not been able to obtain the poison, as yet, in quantities sufficient to enable him to make an ultimate analysis of it. But that it is a chemical body produced by fermentation there can be no doubt.

If there be any doubt about the poison being produced by fermentation, the following experiment would seem to clear it up.

June 26, I took two samples, of one pint each, from a bottle of milk which had already undergone the lactic acid fermentation. These samples were placed in clean glass graduates. To one, a piece of the solid portion of the poisonous custard, about the size of a filbert, and which had been washed with distilled water, was added. To the other no addition was made. These samples

stood side by side for forty-eight hours. Both were then tested for tyrotoxicon. The one to which no addition was made gave no crystals, no odor, and when given to a cat produced no effect. The one to which the addition had been made yielded crystals which had the odor of tyrotoxicon, and which, when given to a very large old cat, produced frothing at the mouth and retching, but no vomiting or diarrhœa, and the next day the animal was able to eat food and seemed to have recovered. I am quite certain that had this been administered to a young animal, the result would have been more marked.

It is well known that milk, while undergoing the lactic acid fermentation, does not possess any such poisonous properties as those belonging to tyrotoxicon. There is no evidence, then, that the poison is connected in any way with the ordinary decomposition of milk. The following extracts from a letter just received from the maker of the Lawton cream show that the attention given to the milk and vessels was all that could be desired:

"The milk of which the cream was made was fresh and sweet morning's milk, only reserving with it the cream of the milk of the night before from the same cows. The milk is kept in a cool clean milk cellar. The custard was made about noon that day, and immediately afterward the process of freezing was begun. The vessels were all thoroughly cleaned. There was no possibility of any impurities adhering to them, for they were scalded, wiped, and dried before being used. The only ingredients used were the milk, cream, eggs, sugar (best granulated), and the flavoring.

"The lemon cream was frozen first, then taken out, put into the packers, and packed solid with ice and salt. Then the vanilla cream was frozen in the same manner. I used the best Jenning's extract, about the usual quantity, not in excess. The cream was eaten in the evening by many people of the village. All of those who ate of the vanilla cream were made sick, and none of those who ate of the lemon cream suffered any inconvenience.

"Now, the milk was the same in both, milked from the same cows the same morning that the cream was made, so that there was no difference in the custard used in making the vanilla cream and the lemon cream, but it turned out that the one made people sick and the other did not.

"We have continued making cream since in the same manner without the least change of the ingredients or the apparatus, except we have not used vanilla extract, but lemon and pineapple, and it has been freely eaten and no one has been made sick by it.

"Clearly in my mind the milk does not account for the trouble. One thing further: Of course, the cream which you examined has been made since the ninth day of June, and may have undergone changes which would result in generating the poison referred to in the papers (certain newspaper accounts of the finding of the poison), and which would not have been found in the cream had it been examined when fresh.

"If there is anything farther that I can furnish you in regard to facts or circumstances in connection with this ice cream, I will be willing at any and all times to give the fullest information possible. Hoping to receive the correct analysis soon, I remain yours respectfully, J. W. JOHNSON."

That the poison which I found in the cream was the same as that which affected the people cannot be doubted after comparing the symptoms produced in the cat with those observed by Dr. Moffitt, and as has been stated the experiment on the cat was made before I received the letter from Dr. Moffitt. The cream was made on the 9th of June, and the poison separated on the 14th.

I wrote to Mr. Johnson asking several questions, which he has kindly and fully answered. As the nature of the questions is shown in the answers, I will simply give the answers:

"(1.) The milk from all the cows was mixed together in the making of the custard.

"(2.) The custard for the lemon and vanilla was all one custard; made and mixed before the extracts were put in.

"(3.) We had previously used the same brands of extracts (Jenning's best), both lemon and vanilla, with no bad results.

"(4.) The food of the cows in the morning and evening consists of oats and corn, ground together and fed dry, with clover hay. I have never seen anything suspicious in the pasture or food. There is a running stream of water, coming from a spring, in the pasture. There is plenty of shade. At evening the cows are driven from the pasture and placed in the stable or yard, according to the season. The stable and yard are open for inspection at any time. My residence is in the center of the village, and the Board of Health would not allow me to stable and yard my cows there if there were any bad odors during the summer.

"(6.) The teats are thoroughly washed before each milking."

After receiving the above details concerning the making of the cream, the following experiment was made:

July 8.—To one quart of night's milk a piece of the solid portion of the Lawton cream, about the size of a filbert, was added. This residue had been left in the filter paper ever since the analysis of the poisonous cream, June 14, and it was on June 8 that the first milk for the preparation of the Lawton cream was collected. This dried and hardened lump was crumbled into the milk, which was placed in a clean tin pan and set in a cool cellar. July 9, to a quart of morning's milk, another small bit of the infected material was added, and this milk was also placed in the cellar. At 1 P. M. both portions of milk were poured into a clean earthenware jar, and four fresh eggs beaten, and one pint of granulated sugar were added. The whole was thoroughly agitated, then allowed to stand at the temperature of the room until 4 P. M., when it was placed in the ice box of a refrigerator, surrounded by ice and here kept until 7 A. M. the next morning, July 10. Then three ounces of the custard was stirred up with distilled water, filtered, the filtrate rendered alkaline and agitated with ether. The residue on the evaporation of the ether was dissolved in a little water and given to a kitten about two months old. Immediately the kitten manifested the symptoms of poisoning by tyrotoxicon, which have already been described. I began the analysis of this custard in the morning before having my breakfast, and getting a little on my finger in carrying the jar, I tasted of it. Within a very few minutes I was nauseated, and ten minutes after taking it I vomited. The prompt action of so small a quantity was probably due to the condition of my stomach.

At 2 P. M. of the same day I took one teaspoonful of the custard. Within thirty minutes there was marked nausea and some violent retching, but no vomiting. At three o'clock, the symptoms having abated, I took a tablespoonful more of the custard. At about half-past three I began to vomit freely. The nausea continued for about an hour. After this there would be passing sensations of sickness. At 8 P. M., while visiting a patient, I was taken very suddenly and sharply with nausea and griping pains in the abdomen. I again vomited and had one watery stool. After this there was no farther trouble. The occipital headache, mentioned by Dr. Moffitt in his letter, was very marked for some hours after taking the custard. It consisted of sharp, lancinating pains which were confined wholly to the occiput. The nausea was peculiar. I cannot say that there was pain in the stomach. A sickening taste would be felt in the mouth and a peculiar, very sickening odor, which I recognized as that of the isolated poison, would intensify the nausea. The throat and mouth seemed filled with a sticky, tenacious mucus. In short, the effects on these parts resembled those which I have experienced from an overdose of atropia.

I think that this experiment explains the poisonous nature of the vanilla cream. The fermentation going on in the custard, and probably begun in the milk, was arrested in that part flavored with lemon by the freezing which was begun immediately. But while the lemon cream was being frozen that part of the custard which was to be made into vanilla cream continued to ferment, and before the freezing process was begun enough of the poison was generated to seriously affect those eating of it.

It should be remarked that in the custard which I made there was nothing peculiar in the taste. It was sweet and pleasant. But, while it was not at all acid to the taste, it gave a decidedly acid reaction as tested by litmus, and was not amphoteric in reaction, as cow's milk frequently is.

It is possible that the presence of the large amount of albumen in the custard, from the eggs, hastened the fermentation. I believe that makers of cheese have found by experience that a large amount of albumen in cheese renders decomposition more easy.

How the special germ which produces the poison found its way into the Lawton cream I cannot say; but that it was either present in the milk or was contained in the eggs used, I think cannot now be doubted.

TYROTOXICON AND CHOLERA INFANTUM.

I desire to call attention to the great similarity between symptoms of poisoning by tyrotoxicon and those of cholera infantum. I am aware of the fact that the term "cholera infantum" is used by many in referring to almost any summer diarrhœa of children; but restricting the term to the violent choleraic diarrhœa, as is done by Smith and other best authorities on the subject, we shall find its similarity to poisoning by tyrotoxicon very marked.

The suddenness and violence of the attack, the nausea and vomiting without marked tenderness of the abdomen, the character of the stools, the great thirst, the severe pain in the back of the head, the nervous prostration, and the tendency to deep sleep, are all observed in both. Again, the white, soggy appearance of the mucous membrane of the stomach of the cat corresponds exactly with observations in children after death from cholera infantum. Cholera infantum, as is stated by Smith, "is a disease of the summer months; and, with exceptional cases, of the cities." Thus, the disease occurs at a time when decomposition of milk takes place most readily. It occurs at places where absolutely fresh milk often cannot be obtained. It is most prevalent among classes of people whose surroundings are most favorable to fermentative changes. It is most certainly fatal at an age when there is the greatest dependence upon milk as a food, and when, on account of the rapid development of intestinal follicles, there is the greatest susceptibility to the action of an irritant poison, and when irritative and nervous fevers are most easily induced. If all these facts be taken into consideration, along with the experiments which have been detailed, and which show the readiness with which the poison can be generated, it will certainly seem at least probable to any one that tyrotoxicon may be a cause of cholera infantum. A little dried milk formed along the seam of a tin pail, or a rubber nipple, tube, or nursing bottle not thoroughly cleansed, may be the means of generating, in a large quantity of milk enough of the poison to render it highly harmful to children. The high temperature observed in children with cholera infantum, and which has not been observed in adults poisoned by tyrotoxicon, may be caused by the continued production of the poison in the child's intestine, by the continued administration of milk, and by the greater susceptibility of the sympathetic nervous system in children.

If this causal relation does exist between tyrotoxicon and cholera infantum, a knowledge of it will aid us, not only in the preventive, but in the curative, treatment of the disease. The first thing to do in the treatment of the disease is to absolutely prohibit the further administration of milk, either good or bad, because the fermentation going on in the intestine would simply be fed by the giving of more milk, even if that milk be of unquestionable purity. I would suggest that some peptone preparation be used for food, though experience will soon give us valuable information on this point.

A germ which forms a poisonous ptomaine by its growth in milk may be wholly harmless when placed in a peptone solution.

Secondly, mild antacids should be administered, because the poison, so far as our information goes, is produced only in acid solutions. The great value of the chalk mixture in the treatment of the disease is well known.

Thirdly, theoretically at least, the employment of small doses of some disinfectant would be of benefit. I find that there is considerable difference of opinion in the profession as to the use of small doses of calomel in this disease.

Fourthly, the use of opium in some form is consistent with the theory.

And, lastly, the administration of stimulants—brandy and ammonia—to counteract the depressing effects of the poison already formed and absorbed, should be practiced.

All of these, save the first recommendation, have been practiced in the treatment of the disease empirically; but the first—absolute discontinuance of the use of milk—I regard as of prime importance.

Of course, it will be understood that attention to securing fresh air, and to other hygienic measures, is also desirable.

It is altogether probable that an amount of the poison which would escape chemical detection might be sufficient to produce poisonous effects in children.

Ann Arbor, July 12, 1886.

—*The Sanitary News.*

PHOTOGRAPHIC DETERMINATIONS OF STELLAR POSITIONS.*

By B. A. GOULD.

IT has been suggested that a short account of my work upon stellar photographs for the attainment of accurate observations might be acceptable to the astronomical section. My intention had been to attend this meeting as a listener and learner only; but I comply with the suggestion the more readily, since, by a notable coincidence, I spoke upon the same subject in this place just twenty years ago, this week. It is true that my communication then was only an oral one and never reduced to writing; for the successful establishment of the Atlantic cable, of which I had received notice that day, called me away suddenly, before the time fixed for the regular presentation; but an elaborate written memoir upon the subject had been presented to the National Academy, ten days previous, at Northampton.

The early history of celestial photography is demonstrably and exclusively American; and its use as a method of delicate quantitative research is very markedly so. Without entering upon the historical data, which are of easy access to every investigator, I may mention that No. 77 of the *Astronomical Journal* contained nineteen photographic impressions of as many different phases of the solar eclipse of 1854, May 26—the moment of each impression being given to the nearest tenth of a second. These were taken at West Point, under the direction of Prof. Bartlett, of the U. S. Military Academy, and form a part of his memoir, in which he also gives the distances between the cusps, as measured by himself with the micrometer in the telescope. Ten years later, in 1864, Mr. Rutherfurd constructed the 11¼ inch photographic object glass which has acquired so conspicuous a place in astronomical history; and with this, in addition to its other achievements, he obtained sharp photographic stellar images with a definition previously unknown, taking for the first time distinct impressions of stars invisible to the naked eye—in fact, to the 8¾ magnitude for white stars.

After constructing a micrometer of great delicacy for the measurement of these plates, he measured with this the relative distances and position angles of the stars which they contained. And in the spring of 1866, he kindly placed in my hands the results thus derived from three plates of the Pleiades, each containing two impressions, taken on the evening of March 10. One of these plates contained forty stars. Bessel's memoir upon the Pleiades, published in 1844, gave the relative positions of 54 stars, measured with the Konigsberg heliometer, during the years 1829 to 1841. Six of these 54 do not belong within the limits of the plate (which contains about one square degree), and 10 of them are too faint for the photographic record, so that 16 of Bessel's list are wanting; but, on the other hand, there are two additional ones, not observed by him.

From this fact alone it may be perceived that among the great benefits which astronomy may be justified in expecting from celestial photography, the accurate determination of magnitudes does not find place. The chemical action of the stellar light upon the film is so dependent upon the character of that light that, in the absence of a correct knowledge of its composition, we are very easily deceived regarding the amount. Thus one of Bessel's stars which was not recorded upon any of Mr. Rutherfurd's plates is estimated by Argelander as of the magnitude 8·0, and by Wolf as 7¾, while five are distinctly recorded which Argelander calls 8½ or less, and eight which Wolf so estimates. The spectroscope would doubtless show a deficiency of the more refrangible rays in the light of the former, and a preponderance of the same in that of the latter.

This series of measurements by Mr. Rutherfurd, together with the computations to which the results were submitted, constitute, if I am not mistaken, the first application of the photographic method to exact astronomical determinations. And the investigation necessarily demanded especial care, both for guarding the numerical results against sources of unsuspected error and for fixing the limits within which known theoretical errors would remain unappreciable.

The importance of the successful application of a method so different from all previous ones, and so full of promise, and also the considerable time which would inevitably elapse before the memoir could be printed, led me at the same time to communicate to the Astronomische Nachrichten, at Altona, some of the resultant values. In a comparatively short note, written about the middle of August, 1866, I gave for the ten most conspicuous stars of the Pleiades, after Alcyone, the corrections derived from one of the photographic plates of March 10, for the values, published by Bessel, for the position angles and distances from Alcyone in 1840; as likewise the average discordance found for a single measure.

In the next following year the Academy had not the means of printing its memoirs; and as, in the mean while, Mr. Rutherfurd had measured five more of the plates of the Pleiades previously taken, as well as six additional ones taken in the months of January and February, 1867, these were also computed, and the re-

* Presented at the Buffalo meeting of the American Association for the Advancement of Science, August 20, 1886.

sults added to those from the first three plates in the memoir already written.

Various circumstances combined to delay the publication, chief among them being what seemed to me a manifest impropriety in printing the results derived from photographs and measurements made by Mr. Rutherfurd, and by his own methods, before some account of these methods should have been published by him. His communication on the subject had been made to the National Academy immediately previous to my own, but was not yet in such form as he desired for publication.

The result showed a very remarkable accordance with Bessel's determination for 1840, although the total amount of relative proper motion during the elapsed 26 years was comprised in the differences.

This memoir still remains in its original form, but unpublished; the results being deduced from 24 photographic impressions upon 14 plates.

In the next year, 1868, I had the gratification of receiving from Mr. Rutherfurd the results of his measurements of 32 stars of the cluster Præsepe, derived from 11 impressions. These were computed in the same way that those of the Pleiades had been, and an analogous memoir upon this cluster was prepared for the National Academy.

Before leaving the country, early in 1870, I gave these two memoirs to Mr. Rutherfurd, with the request that he would send them to the printer, at the same time with his own paper, already mentioned; but not before then. The condition of his health prevented him from attending to the matter for some time; and in the interval, he arrived at the unpleasant discovery that the screw of his micrometer had suffered from wear, and to an extent which led him to fear a want of that accuracy of which the method is susceptible, and which he hoped to see demonstrated by its very first applications.

Notwithstanding this possible blemish, it seems to me that the results ought to be now made public in their original form, after due mention of the circumstances; and it is among my hopes to be able soon to publish these two memoirs from the original manuscript of so many years ago.

The method was received with manifest distrust and disregard abroad; and, as was but natural for so essential a deviation from former methods, very many grounds of criticism and objection were brought up. One of the principal of these was the possible distortion of the collodion film, after receiving the impressions and before the measurements; but Mr. Rutherfurd speedily disposed of this point, at least so far as the albumenized plates are concerned; and, moreover, the combination of measurements of the same stars derived from various plates will at once make manifest the degree of confidence to which the several values and their wear are respectively entitled.

A far more serious obstacle to accuracy is presented by the difficulty of obtaining absolutely round images. Irregularity of form in the dots formed by the stellar impressions is almost incompatible with precision of measurement; and, as the time of exposure must often be long, the chief problem was, not so much to obtain the images as to insure uniformity of motion in the telescope during the period of exposure. Not that the photographic processes were not troublesome enough before the introduction of the dry-plate processes, for very great care and numerous precautions were often necessary to prevent the plates from drying too fast; but far the greatest difficulty consisted in obtaining sufficient precision in the clockwork and equatorial motion of the telescope.

It may easily be imagined how great was my desire, when leaving home for South America, to extend this new method of observation to the southern hemisphere. But the obstacles encountered in the endeavor cannot be easily imagined. Upon these I will not enlarge here further than by saying that, in Cordoba, also, the attainment of circular dots for the star images offered incomparably the greatest of all the difficulties of a practical character. The time of exposure was limited by the maximum size allowable for the large stars, and, previous to 1878, also by the drying of the plate, although exposures of twenty minutes were not unusual. Nevertheless, by dint of specially constructed governors and regulators, and by ceaseless attention, we did succeed in obtaining impressions which, to the unaided eye, appear absolutely round.

This necessity of long-continued and minute uniformity in the motion of the telescope is, of course, largely diminished by the employment of instruments of large aperture, inasmuch as the necessary time of exposure is diminished in the same ratio in which the amount of light is increased. It is yet further and most notably diminished by the manifold greater sensitiveness of the dry gelatine plates. But notwithstanding all this, the attainment of round images, while almost indispensable for giving to stellar photography that increased accuracy to which it may lay claim as a means of research in practical astronomy, still demands especial care and precaution.

The Argentine Government cordially afforded every assistance which I deemed it proper to ask for these investigations. And although the chief energies of the Cordoba Observatory were absorbed by those investigations for which the institution was established, I had the satisfaction of obtaining a sufficient number of stellar photographs to occupy not only my own lifetime, but many more, in their measurement and proper computation.

We photographed no northern stars there except the Pleiades and the Præsepe. Of the Pleiades I brought home sixteen plates, with two impressions of the whole group upon each, made in five different years, from 1872 to 1882, inclusive. Although the center of the cluster never attains a greater altitude at Cordoba than 34° 50′, some of the plates contain 70 stars. All but one of Bessel's stars are there, which belong within the limits of the field, the missing one being of the magnitude 9½, and there are yet other stars of the magnitudes 10, 10½, and 11. Of the Præsepe, there are five plates, and with a correspondingly increased number of stars.

About seventy southern clusters have been repeatedly photographed at Cordoba, comprising all those of the southern hemisphere which seemed important, also somewhat more than a hundred double stars, being a sufficient number to serve as a good test of the method. The total number of photographs now on hand is somewhat less than 1,300, only few having been preserved in which the images were not circular.

Especial attention, however, was given, for many years, to taking frequent impressions, at the proper seasons, of four stars selected, on account of their large proper motion, as likely to manifest appreciable annual parallaxes. The refined and elaborate observations of Drs. Gill and Elkin, at Cape Town, have been made, computed, and published, while the Cordoba photographs have lain untouched in their boxes. There is but one of any four stars, Beta Hydri, which is not included in their list. Still it will be a matter of much interest to apply the photographic investigation to the same problem, even if for no other purpose than a comparison of the results of the two methods.

I am convinced that the Cordoba plates contain a large number of stars as faint as the eleventh magnitude of Argelander's scale, and believe that these are much the earliest photographs of stars fainter than Mr. Rutherfurd's of 1865 and 1866. There are several plates, covering about a degree square, which cannot contain less than 550 stars, and I believe that some of them contain a greater number. Such are those of the cluster Lac. 4,375 and that near X Carinæ.

The region in the vicinity of Eta Carinæ, and that magnificent tract in Sagittarius which is too densely sown with stars to be considered merely a portion of the Milky Way, and yet too large and undefined to be regarded simply as a cluster, were both of them taken several times, during the years 1875 to 1882, in series of overlapping photographs, each containing about a square degree, and recorded upon a glass surface of 9 by 12 cm. In their present form they are of course of small value for scientific use, inasmuch as the stars are too crowded for their configurations to be easily perceived; and, although these two series form in fact maps of considerable regions in the sky, still the record is of a very perishable nature, and of small avail for use by astronomers until it shall have been translated into an enduring and numerical form by micrometric measurement.

In this connection I may say that one of the greatest of my present anxieties regarding the Cordoba photographs arises from a discovery of the ease with which the collodion or gelatine film may become detached from the glass. The Argentine Government has assigned a moderate sum for the prosecution of the measurements, and with this some progress has already been made. It is but right to add that the full amount was given for which I asked. Still it is now quite inadequate, in consequence of the unfortunate depreciation of the national currency; and, in the present financial crisis there, I cannot reasonably expect more. Yet this matter of prompt measurement appears to me at present much more important than it did while I was unaware of the facility with which the film can blister and peel.

In 1883, after Mr. Common's brilliant success in photographing nebulas with his great three-foot reflector, he proposed to me a joint arrangement for photographing the whole heavens. My work at Cordoba was so near its close that it was out of the question to undertake anything new; but the immense labor requisite for the measurement of the plates would, under any circumstances, have tended to deter me. It is an undertaking demanding the joint energy, application, and material resources of a large number of persons, if the results are to be made available for astronomical use; indeed, I see no other astronomical value in the unmeasured photographs than the possibility of confirming at some future epoch the existence of relative motion previously detected or made probable by some other investigation.

Since then, the process of photographic charting is said to have been systematically undertaken by the Brothers Henry, at Paris. I have seen none of their plates; but their sharpness is highly spoken of, and the work appears to be prosecuted with much skill and very sensitive plates. There can of course be no question as to the value of any permanent record whatsoever, corresponding to a known date; yet I cannot feel that any essential advance is likely to be made in this way until the photographic record shall have been brought within the range of numerical expression.

The measurements of the Cordoba photographs, thus far completed, are those of the double stars, the four stars with large proper motion, of the Pleiades, of the Præsepe, and of the clusters Lac. 4,375 and Kappa Crucis. The corresponding computations have been made, as yet, only for a portion of the Pleiades impressions, but I am hopeful of completing all these at a comparatively early date. We shall then be able not only to compare the results with Bessel's of 45 years ago, but to test the deduced values of the proper motions by means of the photographic determinations of 1865 and 1866. Meanwhile the valuable memoir of Wolf has been published, giving closely approximate positions for 571 stars of the group, and Dr. Elkin has recently been executing at New Haven a heliometric triangulation of the principal stars. Our photographic results will have to be confronted with his delicate heliometric ones; and should they bear this test with tolerable success, it will be all that can reasonably be desired.

STEEL VS. IRON FOR CARRIAGE WORK.

The average intelligent carriage smith is no more puzzled in the working and welding of steel than he is with the same treatment of iron.

The Bessemer process, by its ready and cheap rendering of crude pig iron into merchantable bars of steel, has revolutionized the steel trade. Cheaper methods and a better product is the aim of many. The carbonization to a limited extent of bar iron is the great theme, a method which will dispense with heavy and costly machinery, and one which has met with very fair results at the present time.

Steel can be made from Danemora bars or blooms, and placed on the market at a cost so trifling above the cost of Norway shapes as to not reach more than a few dollars per ton. The product in question is equal in all strains of a tensile, torsional, or impact character to the best of Norway iron the world produces; while the resisting force in transverse strains is much greater.

We were present, a few days since, at the testing of a number of celebrated brands of this new mild steel, which, sooner or later, will usurp the place of iron. Some were of foreign manufacture and others domestic, among which was a "silver steel" by the Catasauqua Steel Co., and mild steel by the Atho Steel Works, of Newark, N. J.; there was also a number of other very excellent brands. We took a sample bar, and forged from the same a set of dash heels for a buggy, and when cold subjected them to all sorts of strain without fracture. We heated the same to about 700°, and cooled in cold water, and again put the forgings through another set of tests, and still no fracture. Welds were made, and swaged, and cooled off, while at 500°, and could not be broken any more than could the same made of Norway. It was as easy to weld without flux as any ordinary iron. There was a density or hardness about it while forging it that follows in the working of "Low Moor" iron. When cold, it is much stiffer than Norway, but will bend under a heavy pressure without breaking. It swages much smoother than iron, and consequently requires less filing or grinding. In the lathe, or on the planer, a smoother cut is made than with any known iron. Forgings can be made lighter with it than with iron, and still stand greater pressure or strain without bending.

We next had a piece lathed and casehardened with bone dust, which was afterward put through the buffing process, with a view to show up seams, dirt, or looseness. The result was—not a blemish could be detested. After nicking with a cold chisel, we tried its breaking qualities over the sharp corner of the anvil, and after more than a dozen vigorous blows with a 14 pound hammer, failed to break the specimen.

With all these facts before us, we come to the conclusion that at last the carriage builder has reached a proper metal for the production of his wares, provided the manufacturers will study their own interests by putting the same on the market in merchantable sizes.

For axles, the spindles of which may be tempered, and for axle boxes, we do not know of a better metal. For all work which is subject to all sorts of adverse strains it has no superior, if it has an honest equal, which we doubt. It would be impossible to find a better article for rocker plates. For polished work, pole crabs, lead bar fixtures, cock eyes, ferrules, door handles, or any other furniture in the carriage line, it has no superior. The fact of the matter—it is just what we want, and we want it right away, that is, if we can get it; and there is no plausible reason why we should not.—*Carriage Monthly.*

PAPER WATER PIPES.

Gas and water service pipes, made of paper, have recently been exhibited in Vienna. These pipes are made in the following manner: Strips of paper, the width of which corresponds with the length of one pipe section, are drawn through melted asphalt, and then wound upon a mandrel. When the pipe thus formed has become cool, it is pulled off the mandrel, and the inside is covered with a kind of enamel, the composition of which is kept a secret. The outside is painted with asphalt varnish, and dusted over with sand. It is stated that such a pipe will resist some 2,000 pounds internal pressure, although the thickness of the material is only about half an inch. It is also claimed that the pipes are likely to be useful for various factory purposes, and for laying electric cables.

EXPERIMENTS TOWARD THE ANIMAL BATTERY.

THE ANIMAL DIELECTRIC.

The subject which has had the first place in my work during the past quarter is the attempt to arrive at a correct idea of the structure, whatever it may be, which in the living body is capable of acting as a dielectric. If the living body is an electrical organization in true as distinct from symbolical representation, then the dielectric must be found within the organism, and must be proved there, before the secret of action can be disclosed. The dielectric is the electric substance. The two electricities cannot exist without it; there can be no phenomena without it.

In the obscurity which prevails, we might assume that the hypothesis of the animal body being an electrical organism is a pure chimera, and that the authority of even Faraday himself might be set aside in support of such an hypothesis, until something more than has yet been discovered is brought to light. I admit, at once, what many feel, that much of the experimental argument which has been expended on animal electricity, laborious, laboriously technical, and studiedly learned though it may be, is so much verbiage until a working solution of the difficulty has been made out. If the animal machine, in life, is an electrical machine, why can we not set it working like any other electrical apparatus? Or, if we cannot go so far as this, why cannot we determine the elements of the machine, and, as we would with a machine constructed by men, define the parts of it and their duties? Is there a primary battery, and, if there is, where? Is there a storage or secondary apparatus, and, if so, where? Are there conductors, and, if so, where? Is there a dielectric structure for a machine, and, if so, where?

In the fully organized body of a living animal, all these elementary questions are so confused or concealed, we might, I repeat, hesitate altogether did they stand alone. But, fortunately, there is in nature the most perfect evidence of the existence of an organic electrical apparatus, evolved by nature herself, worked by mental impulses, and playing the part so clearly of a statical apparatus yielding electrical phenomena, that we know the thing is done, although we do not, even there, know *how* it is done. In the electric eel, to which I now refer, we actually have the apparatus before us, and yet we do not comprehend the method by which it is worked; we feel the shocks the machine gives, and yet do not see how the charge is laid, nor, in a physiological point of view, how it is delivered.

I have had under observation the effects of the shock from two live electric eels. From one of them I took a shock sufficient to communicate a stun from the palm of my right hand through the arm to the shoulder, and across the fore part of the chest. I saw a similar shock from the same animal strike into insensibility the carp which are intended for its food.

After testing the shock which one of these animals

expended on my own body—receiving the shock from my left hand—I fitted up an ordinary Leyden jar, and charged it so that it produced, to my sense, the precise power of the shock which the vital Leyden jar had produced. Between the two kinds of shock there was only one point of difference.

The shock I took from the eel from my left hand, placed over its body across the electric apparatus, was sharp, painful, and extensive. As I have said, it traversed my arm up to the shoulder and passed across the chest, leaving in all these points an after sensation of numbness, which lasted for a period of five minutes, and subsided very gradually. The shock from an ordinary Leyden gave precisely the same series of effects, with the one difference that on receiving the shock from the body of the eel under the water, my hand seemed to be repelled, while in receiving the shock in air, either from within or without the common Leyden jar, no such effect of repulsion was perceived.

The shock from the vital battery of the electric eel—local on large animals—is sufficient to render small animals coming within its range generally insensible; and the assumed intention of the apparatus is to enable the eel to obtain its prey by the stun which it administers. But the stun itself is not, of necessity, fatal, for small carp swimming near the eel, though they be made instantly insensible by the discharge, may, if they escape being swallowed by their potent enemy, show signs of renewed life very quickly, and in fifteen or twenty minutes may be seen moving about as briskly as if nothing had happened to them.

In my lectures on the physiological effects of the great induction coil at the Royal Polytechnic Exhibition, published in the *Medical Times and Gazette* in the year 1869, I demonstrated that just the same effects—namely, stun and insensibility—could be produced by the common electrical shock of low tension. I showed that a surgical operation could be painlessly performed during the occurrence of this insensibility, with recovery as a result, in the same way as under anæsthesia from chloroform.

These observations are confirmatory of those made, long since, by Hunter, Walsh, and John Davy, as to the identity of the electric discharge from the living organic battery in the electric eel and the discharge of low tension from the Leyden jar. But I only refer to them here to indicate that in this vital battery, which is as truly a condenser as a Leyden apparatus, there must be a dielectric, and that from analogy there may be a dielectric playing the most vital of functions in the living body of all animals.

I have tried to arrive at the solution of this scientific puzzle—whether there is such a dielectric—by the exclusion process. We may take it as a safe argument that whatever part of the body will readily conduct a current, is not a dielectric. With a charge of low tension I have, therefore, tested the structures of the animal body to exclude every one that will play the part of a conductor, and to find if any one failing in conduction will play the part of a dielectric, like glass or sulphur, in connection with a conductor on its opposing surfaces. The results may be epitomized as follows:

Blood, either arterial or venous, either in its ordinary fluid form or condensed in any degree, or condensed by slow evaporation until it is semi-solid, or condensed by freezing until it is solid, fails to play the part. Under all these conditions, blood conducts, differing from water in that it conducts better than water—owing probably to the iron it contains—when solidified by cold, *i. e.*, frozen.

Bone, while it resists a voltaic current of low tension, fails to play the part. It permits the passage of discharge from the machine, and this although its structure be dried until it ceases to lose weight. The metal calcium in bone is probably sufficient to account for this result.

Membranes from all parts and organs, while they are in the state of hydration in which they exist in the living body, fail to act as dielectrics. The membrane which incloses fat offers most resistance to the voltaic current, but is quite useless as an insulator to a discharge from the machine. The vascular membranes, like the pia mater, are altogether out of the question. They conduct as readily as blood.

The structures of all the *vascular organs*, liver, kidney, spleen, lung, are in like manner negative as dielectrics. They all conduct.

Muscular structure is alike negative.

Fat reduced by cold to an extremely solid state, to such solidity that the body could not move in it, plays the part of a dielectric. But fluidified by warmth, so as to become as flexible as it is in the body, it loses its insulating power to the discharge from the machine, although it retains it until the fluidity is much more complete in respect to the voltaic current.

The secretions of the body, the urine, the sweat, the bile, the saliva, the mucus, the tears, are negative. They all conduct.

The gelatinous structures are all negative.

The nervous matter is the last and most important structure for inquiry. The gray matter plays no part as a dielectric. It conducts readily both the voltaic current and the discharge from the machine. The white matter of the nervous substance is different. It acts more after the manner of a crystalline fat—like spermaceti—as a dielectric, than any other substance in the body. The difficulty of determining whether or not it is dielectric depends on the difficulty of separating it in the moist and fresh state from all connection of gray matter, of blood, and of membrane, for the purpose of securing a definite experimental result.

Proceeding by manner of compound synthesis, as explained in a previous number (*Asclepiad* for January, 1886, pp. 75–87), I obtained the body of a large eel, that had been killed in the usual way by decapitation, and cut from the body transversely a portion four inches in length. I placed this portion of the body of the eel upright in a glass vessel nearly filled with pure fluid paraffine. I then passed down the center of the spinal cord a length of fine platinum wire, permitted the wire to stand three inches above the level of the paraffine, and to terminate in a small metal ball. The section of the body of the eel being thus well insulated, I touched the body of it externally with the finger while a charge was given to the metal ball from the positive of the statical machine, and when the charge began to be rejected I withdrew my finger. The cord surrounding the wire was left charged, as in the Leyden jar. On connecting the outer surface of the body of the eel with the earth, a discharge could always be taken from the ball. By suspending a light cotton-wool brush by a thread of silk near to the ball—after charging from the machine—the cotton first attracted to the ball was then vigorously repelled from the ball, and afterward made revolutions around the ball until the charge was used up. In some instances, after storing the organic battery in this way, I retained the charge for twelve hours, and then used it up in the work of moving the cotton-wool brush. In many instances, by waiting after the battery seemed discharged, I got a forcible reserve discharge. These results could be repeated until they were disturbed by the decomposition of the animal structure.

In another series of inquiries I took the brain of the sheep after death, and letting it harden in alcohol until it could be cut into thin and even slices, I made longitudinal sections of it, so as to get sets of plates of varying thicknesses. I then very carefully coated these sections with gold leaf on each side over the surface of white matter, taking care to keep the edges of the leaf at least a fourth of an inch from any point of the margin of gray substance. Laying the sections on an earthenware plate, with metallic connection from the under gold leaf, so as to make communication with the earth through the finger, I tried to charge from the upper gold leaf by the positive terminal of the machine. The results were very curious. With plates the tenth of an inch in thickness the discharge always passed through directly, so as to communicate a slight shock to the finger; with plates the fifth of an inch thick the shock had to be rendered more intense for it to pass; and with sections a quarter inch thick there was no transmission at all. At the same time the condensation was very imperfect and very uncertain.

The research here is more than usually important. If it should prove that the white nervous substance is capable during life of acting as a condenser, after the manner of the secondary organic condenser which exists in the electric apparatus of the electric eel, the functions of the nervous system would be read in a much more simple form than they are at this time. The fact would indicate that the nervous matter capable of being charged is all charged by induction from the surrounding media, and a nervous cord, instead of being considered a conductor, in the common sense of that term, would be a cord extending from the centers charged, like them, by induction. In short, the whole nervous system standing alone would be a condenser charged by induction from the blood, the vascular membranes, and the arterial pulsations, and giving out its force, as demands are made upon it, to excite all movements. The spinal cord, with its vascular gray center and investing vascular membrane, would be in the position of a Leyden condenser; the brain, with its ventricular fluid and plexuses within, and vascular covering and gray matter without, would be a great central condenser; and every nerve following a pulsating artery, and connected with it, would be a peripheral condenser.

There is much indirect indication of the correctness of this conception. At every minute of our lives the great arterial system is actively communicating to every part, central and peripheral, from sixty to eighty vibrations which can be objectively demonstrated, but are not subjectively felt. How are these vibrations absorbed, except by the nervous structure? Where are they stowed away, except in the white nervous fiber or in some subtile medium which that fiber secretes and holds? And these vibrations are, practically, life. In the experiment I have described in *Asclepiad*, vol. ii., pp. 180–182, in which I was trying to resuscitate an animal recently dead, I got the most remarkable approach to success on record by the process of injecting over the arterial channels fresh blood in vibrating or pulsating current. In this experiment the phenomena of life temporarily returned. They were not permanent, because they depended on my artificial pulse instead of the natural animal battery which produces them in life; but they were declared for the time, and so far cleared the way for further advance toward their prime source.

I am brought back at this point to a theory which I put forward under the title "A Nervous Atmosphere or Ether" (*Medical Times and Gazette*, vol. ii., p. 113, for 1867, and vol. i., p. 507, for 1871), in which the attempt was made to prove that during life and at the natural temperature of the living body, there exists in the nervous fiber an atmosphere in sufficient tension to be susceptible to all mechanical vibrations, and to play the part of an intercommunicating medium between the nervous organism and the outer world. I proceed further now. I venture to suggest that it is located in the white structure of nervous matter; that it possesses the dielectric qualities which are essential to an organic nervous mechanism, as well as of absorbing arterial pulsations and external vibrations presented to the nervous expanses; and that, by its presence, it distinguishes the animate from the inanimate condition of animal matter.—*B. W. Richardson, in The Asclepiad.*

A VOLTAMETER FOR PROLONGING THE ELECTRIC LIGHT AND RENDERING IT REGULAR.

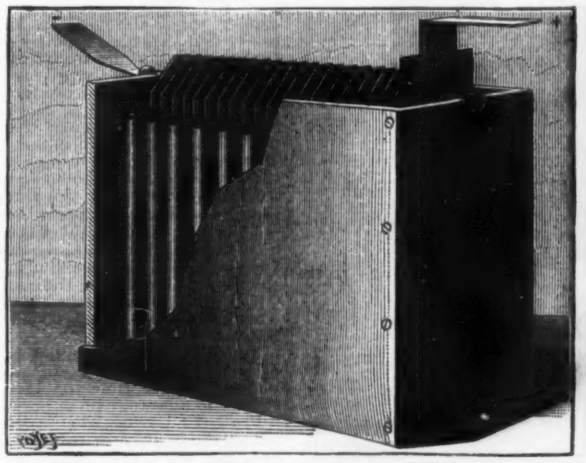
THE velocity of a dynamo electric machine is never absolutely uniform. The rhythmic impulsion of the motor, the defects in transmission, and the variations in resistant work, alternately accelerate and retard its mean rate of running. The variations in electromotive force resulting from these irregularities are more or less marked, according to the degree of perfection of the plant, and more or less endurable, according to the nature of the service required.

If, for example, it concerns lighting through incandescence, slight changes in velocity produce great variations in the brilliancy of the lamps—the luminous intensity being nearly proportional to the *sixth power* of the difference in potential at the two branches of distribution. In large carbon lamps, these irregularities are diminished, on account of the bulk of the luminous part; but in those provided with fine filaments, the use of which is tending to become predominant, the variations in lightness are very marked, and are so much the more troublesome in that they are synchronous in all the lamps.

As well known, accumulators render the current sensibly regular, because the variations in their electromotive force are much less than those of the electromotor that charges them. In accumulators of the Plante type, the superelevation of the difference in potential is but 8 per cent. of the excess of electromotive force of the source.

This explains why electric lighting with accumulators is generally attended with great regularity, even when the mechanical features of the plant are defective. This advantageous influence of secondary batteries upon the running of the machines is not disputed, even by their adversaries.

The sole objection is that this very regularity would be too dearly paid for in cases where we should require of accumulators this service alone, without utilizing their properties as magazines. For circumscribed use such as this, voltameters may be economically substituted for accumulators properly so called.



VOLTAMETER FOR PROLONGING THE ELECTRIC LIGHT.

The regulating power of a secondary battery does not depend upon its electro-chemical capacity, but upon its rate of discharge; in other words, a series of voltameters, slightly or not "formed," will operate as a regulator as well as, and perhaps better than, a battery of accumulators of the same electromotive force and resistance.

The question of capacity being set aside, the manufacture of secondary couples becomes much simplified. At the same time, the selection of combinations is offered a wider field. Besides the Plante couple, which has up to the present been selected for accumulators, other systems may be tried. The zinc-lead couple, for example, offers some important advantages when it is no longer required that the charge shall be preserved for a long time. Its high electromotive force of 2·4 volts, instead 1·9 volt, permits of diminishing the number of the couples and the resistance of the battery. Its variations are still less than those of the lead-lead combination; and, finally, in cases in which a certain capacity might be necessary in order to operate without a machine for from 10 to 30 minutes, in case of an accident, it can be "formed" in a trice, as I shall presently show.

The zinc-lead system has therefore been chosen for my industrial voltameters, which are being constructed by Messrs. A. Poulain & Son, at Charleville. The ordinary model is shown in the annexed cut.

The positive is a long strip of lead, bent in folds, and having a superficies of 2,400 square inches. The negative consists of 21 leaden plates, interposed between the folds of the positive, and suspended from a lead-covered copper collector, which rests upon the edges of the trough. The liquid consists of water acidulated with sulphuric acid, and half saturated with zinc oxide.

Voltameters are placed, like accumulators, on a circuit derived from the principal current, of which they receive a small fraction that keeps them charged.

In order to give these voltameters a certain capacity for accumulation, it suffices to use Mr. Plante's nitric preparation on the positive electrodes, which will thus acquire the property of fixing a notable quantity of oxygen; as for the negative ones, they are "formed" in a trice by a deposit of electrolytic zinc. A battery of voltameters, whose positives have been properly prepared, is capable of prolonging the lighting for a half hour—a sufficient space of time, in most cases, to permit of repairing the accident that caused the stoppage, or, at the least, to take such measures as the situation demands.

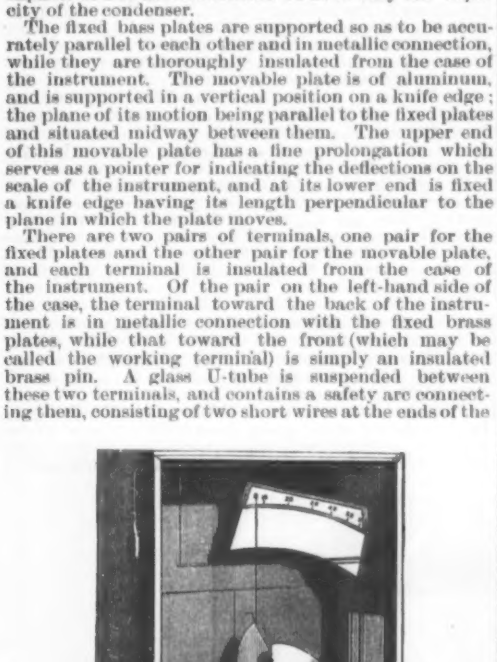
The model here described is capable of rendering a 100 ampere current regular. As its electromotive force is about 2·4 volts, it would take but about 44 voltameters of this model to render regular (and prolong, if need be) the light of 200 Edison lamps of the new 16 candle type, which expend ½ ampere, with a fall in potential of 100 volts. For the same service lead accumulators might be constructed in a double form, and be employed to the number of 55. The saving obtained by the substitution is 70 per cent. So voltameters are destined to replace accumulators in all cases where it is a question merely of rendering a lighting regular, and of taking precautions against sudden extinctions.—*E. Reynier, in La Nature.*

THE ELECTROSTATIC VOLTMETER

CONSISTS of an air condenser with one of its plates capable of a to-and-fro motion so as to vary the capacity of the condenser.

The fixed bass plates are supported so as to be accurately parallel to each other and in metallic connection, while they are thoroughly insulated from the case of the instrument. The movable plate is of aluminum, and is supported in a vertical position on a knife edge; the plane of its motion being parallel to the fixed plates and situated midway between them. The upper end of this movable plate has a fine prolongation which serves as a pointer for indicating the deflections on the scale of the instrument, and at its lower end is fixed a knife edge having its length perpendicular to the plane in which the plate moves.

There are two pairs of terminals, one pair for the fixed plates and the other pair for the movable plate, and each terminal is insulated from the case of the instrument. Of the pair on the left-hand side of the case, the terminal toward the back of the instrument is in metallic connection with the fixed brass plates, while that toward the front (which may be called the working terminal) is simply an insulated brass pin. A glass U-tube is suspended between these two terminals, and contains a safety arc connecting them, consisting of two short wires at the ends of the



SIR WM. THOMSON'S ELECTROSTATIC VOLTMETER. (400 VOLTS TO 10,000 VOLTS.)

U-tube and an intervening length of thread, kept moist by a little water in the bend of the U-tube. The terminal toward the back of the instrument on the right-hand side is in metallic connection, through the V-groove support, with the movable plate; in other respects the pair of terminals on the right is similar to the pair on the left.

In order to save time in taking readings, an arrangement is provided for checking the oscillations of the movable plate, and stops are placed to limit its range and prevent damage to the pointer.

When fixed and movable plates are connected respectively to two points of an electric circuit, between which there exists a difference of potential, the movable plate tends to move so as to augment the electrostatic capacity of the instrument, and the magnitude of the force concerned in any case is proportional to the square of the difference of potential by which it is produced. In the use of the instrument this force of attraction is balanced by the horizontal component of a weight of any convenient amount hung on the knife edge at the bottom of the movable plate.

The scale is graduated from 0 to 60, and the divisions represent equal differences of potential—the actual magnitude of the difference per division being dependent upon the weight in use at the time. A set of three weights is sent with each instrument, of, respectively, 32·5, 97·5, and 390 milligrammes, providing for three grades of measurement in the proportion of 1 : 2 : 4. Thus the instrument shows one division per 50 volts with the link (the lighest weight) alone on; one division per 100 volts with the medium weight hanging on the link, and one division per 200 volts with all three weights on.

To set up the electrostatic voltmeter in working order:

1. Having removed the glass door of the case, place the movable plate or vane on its knife edge support, handling it very carefully lest it be bent or twisted in the operation. A line drawn lengthwise on the surface of the movable plate and passing through its intersection with the knife edge divides the portions above and below the knife edge into unequal parts. When the movable plate is properly placed, this line is just seen behind the vertical edge of the fixed plate when the pointer indicates zero, and the smaller segments of the movable plate are then hidden from a front view by being between the fixed plates.

2. To detect, and if necessary correct, any accidental bending of the pointer, with reference to the attracted portion of the movable plate, hang one of the weights on the lower knife edge; take the round pin sent inside the case, and with it press the movable plate in between the fixed plates until it rests in the two V-notches near the upper end of the vertical edges of the fixed plates; holding the pin so, rotate it about its axis, and observe that the pointer indicates a small thin line, seen on the scale between division-numbers 30 and 40.

3. Remove the weight and see whether the movable plate is in neutral equilibrium, and, if necessary, adjust it to fulfill this condition, by means of the wires for that purpose fixed to the upper end of the plate.

4. Be careful always to use the *working terminals* with safety arc for connecting to the two points whose difference of potential is to be measured, especially if the difference in question be very great, or if a large Leyden battery, or a dynamo, be in connection; as otherwise damage might be done to the instrument.

RECENT RESEARCHES ON METEORITES.

IN the course of a lecture on "Meteorites," recently delivered before the Royal Institution, Professor Dewar gave details respecting some experiments he had been making in connection with extremely low temperatures, such as that of interstellar space. The question had been raised as to what chemical reactions could take place at these temperatures, and in his investigations Professor Dewar had discovered that at a temperature of about 130° C. liquid oxygen has no chemical action upon hydrogen, potassium, sodium, phosphorus, hydriodic acid, or sulphydric acid.

As an example of the low temperatures he could obtain, he exhibited at work the apparatus by which he had recently succeeded in solidifying oxygen for the first time. We illustrate this apparatus in the accompanying diagram, where a copper tube is seen passing through a vessel kept constantly full of ether and solid carbonic acid; ethylene is sent through this tube, and is liquefied by the intense cold; it is then conveyed by the tube, through an India rubber stopper, into the interior lower vessel; the outer one is filled with ether and solid carbonic acid. A continuous copper tube, about 45 ft. long, conveying oxygen, passes first through the outer vessel, and then through that containing the liquid ethylene; the latter evaporates through the space between the two vessels, and thus intense cold is produced, whereby oxygen is liquefied in the tube to the extent occasionally of 22 cubic centimeters at one time. The temperature at which this is effected is about 130° C., at a pressure of 75 atmospheres, but less pressure will suffice. When the oxygen is known to be liquid, by means of a gauge near the oxygen inlet, the valve, A, is opened, and the liquid oxygen rushes into a vacuum in the central glass tube below; some liquid ethylene at the bottom of the next tube outward is also caused to evaporate into a vacuum at the same moment, and instantly some of the liquid oxygen in the central tube becomes solid, owing to the intense cold of the double evaporation. The outer glass vessel serves to keep moisture from settling on the sides of the ethylene tube. By means of the electric lantern and a lens, an image of this part of the apparatus was projected upon the screen, this being the first time that the experiment had been shown on a large scale in public.

Professor Dewar, when performing the experiment before the Royal Institution, said that the temperature obtained was a little below 200° C., that is, only 50° to 70° above the absolute zero of temperature, and that in the experiment about 5 lb. of liquid ethylene were employed.

With reference to the main subject, Professor Dewar said that meteorites came from regions of intense cold into our atmosphere; most of them weigh but a few ounces or pounds, but exceptional meteorites weigh several hundredweight. A spherical body 3 ft. in diameter, moving at the rate of 18 miles a second at the height of 23 miles, where the barometric pressure is only $\frac{3}{10}$ of an inch, produces locally a compression pressure 5,600 times greater than that of the surrounding air. Descending vertically, it would pass through the whole atmosphere in 15 seconds. The velocity stated in these data is relatively low as compared with that of planetary bodies. Meteorites travel at the rate of about 36 miles in a second. The velocity of a shot from a 100 ton gun is about half a mile per second.

Meteorites reach the earth covered with a thin and very remarkable glaze, due to the fusion of their external surface during their brief passage through the atmosphere. A velocity of 145 ft. per second in air gives an increase of 10° temperature, and the rate continues as the square of the velocity. The surface temperature of a body moving at the rate of 39 miles per second would reach 2,000,000°.

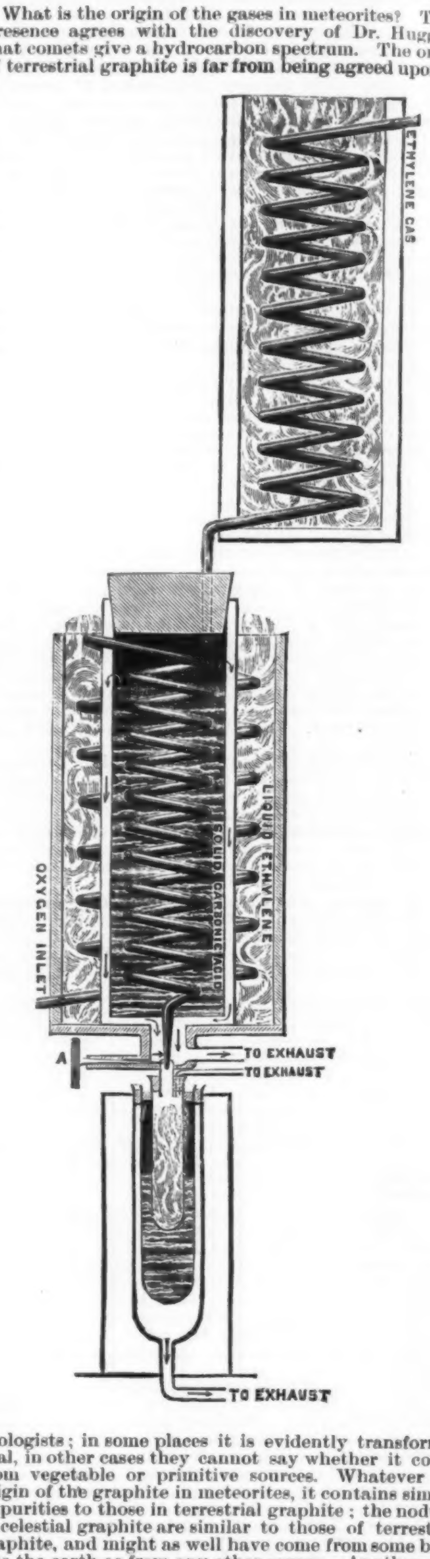
The lecturer placed a piece of iron against a rotating emery wheel, the friction of which caused showers of sparks to be thrown out. These were so hot that some of the little globules of iron composing them were fused into a plate of glass placed to catch them. Professor Dewar believed great similarities to exist between the flight of these globules and the flight of meteorites, the heat and light in both cases being partly due to friction and partly to chemical action. That chemical action has an influence, he proved by applying oxygen gas to the sparks, thereby causing them to burn more brilliantly, and by applying carbonic acid to them, thus reducing their brilliance. When a piece of meteorite was applied to the emery wheel in place of the piece of iron, the sparks were far less abundant, and of a dull red color. The glaze of meteorites can be imitated to some extent by cooling a piece of meteorite to 200° C., and then dropping it for a moment into the electric furnace; the temperature explains the glazing of a meteorite, and that it has a motion of rotation must also be considered in estimating the amount of friction, and therefore of heat, to which it is subjected in its passage through the atmosphere of the earth. An enormous amount of its energy, however, is expended in heating the air, and aerial vibrations thus set up explain the noises made by the passage of meteorites.

In considering the question of the relation of carbon compounds to meteorites, and of the relation of meteoric carbon to natural carbon, Professor Dewar and Mr. Ansdell had made some researches, from which they obtained the accompanying results, as regards the gases contained in meteorites:

GASEOUS PRODUCTS EXTRACTED FROM METEORITES. (DEWAR AND ANSDELL.)

Description of Meteorite.	Occluded Gases in vols. of Meteorite.	Percentage Composition of Gases.				
		Carbonic Acid.	Carbonic Oxide.	Hydrogen.	Marsh Gas.	Nitrogen.
Dhurmsala.........	3·42	58·05	12·06	23·01	3·06	2·02
Poltusk..........	3·54	66·12	5·04	18·14	7·65	2·69
Moes	1·94	64·05	3·09	22·94	4·41	3·67
Orgueil	57·87	12·77	1·96	None.	1·05	0·56

What is the origin of the gases in meteorites? Their presence agrees with the discovery of Dr. Huggins, that comets give a hydrocarbon spectrum. The origin of terrestrial graphite is far from being agreed upon by



geologists; in some places it is evidently transformed coal, in other cases they cannot say whether it comes from vegetable or primitive sources. Whatever the origin of the graphite in meteorites, it contains similar impurities to those in terrestrial graphite; the nodules in celestial graphite are similar to those of terrestrial graphite, and might as well have come from some body like the earth as from any other source. Another conclusion is that the marsh gas is not occluded in meteorites, but is a product of distillation by heat, just as the gas might be distilled from shales. The graphite of meteorites has no power of occluding marsh gas, therefore the inference is that the marsh gas and hydrogen in them are the result of the decomposition of organic bodies. In the spectrum of one of the comets, Dr. Huggins once photographed a peculiar band in the ultra-violet, which band indicated the presence of cyanogen. One meteorite on the table contained chloride of ammonium, therefore it contained a compound of nitrogen, and such presence would account for the production of cyanogen. A meteoric fall before scientific witnesses, Professor Dewar continued, is much to be desired; a stones hould be picked up directly after its fall, and before it has touched water, to give power to deal with the question whether meteorites contain water; if water be one of their constituents, there is the possibility of numerous chemical interac-

tions. Meteorites appear to be of much the same nature as comets, and may indeed be portions of the *débris* of comets trailing behind.—*Industries.*

HISTORY OF THE DISCOVERY OF THE ASTRONOMICAL TELESCOPE.

By E. LAGRANGE.*

I.

AMONG the discoveries in the domain of astronomy and physics, there is, perhaps, none whose origin has given rise to more controversy than that of the telescope. The influence that such discovery has exerted upon the development of astronomical science, and, consequently, upon the conceptions as to the system of the world, is a preponderant one. It is not astonishing, therefore, that the various nations of the continent of Europe have endeavored to lay claims to the fortunate inventor of this instrument of celestial exploration. To tell the truth, the first person who conceived the ingenious idea of combining a set of concavo-concave and convexo-convex lenses must be considered as the author of the discovery. At least a century before the construction of the first telescope, numerous scientists had described and made known certain properties of a combination of two lenses, but not one of these, as far as we have historic proofs of it, devised a practical instrument. It seems to us very improbable, at all events, that a discovery of this kind could have passed unnoticed, when we come to think of the noise that it made throughout Europe when it was announced at the beginning of the seventeenth century.

Some authors have been pleased to refer the invention of the telescope to a much remoter epoch, or even to rob Europe of the glory of it; but none of the evidence furnished by history permits us to conclude upon an extra-European priority of invention. At the epoch in which a number of scientists and inquirers, like Bailly, were endeavoring to fix the origin of a host of recent discoveries upon Oriental peoples, and particularly upon the Chinese, the same was done with the telescope. The warrant of this was an extract from a great encyclopedia, which bears the title of *Wa-kau-san-sai-tsou-ye*, and which appeared in Japan in 1713, after several Chinese editions of it had been published. In this work mention is made of two satellites of Jupiter. This fact, which seems quite extraordinary at first sight, is very simply explained: A large number of observers, and, among them, Boussingault upon the plateau of Bogota, the Marquis of Ormonde upon Etna, Jacob at Madras, and others, have seen a certain number of this planet's satellites with the naked eye, and this disposes of all the pretensions that China or Japan may still put forth upon the basis of a somewhat obscure text.

More than this, Arias Montanus, a celebrated scientist and theologian of the seventeenth century, held the opinion that the telescope was a diabolical invention; and he found a confirmation of it in a passage of the Gospel according to St. Matthew, where it is said that the devil led our Lord to the top of a high mountain, whence he pointed out all the kingdoms of the earth and their splendor. Montanus concluded from this that the devil was provided with a telescope!

I do not know who, feeling authorized by a passage in Diodorus Siculus, attributed a knowledge of this instrument to the ancients. Diodorus tells us that Hecatæus of Miletus mentions in his writings an island to the north of the country of the Celts, whose inhabitants are all priests of Apollo. The moon is so near this country that mountains can be recognized on its surface. Some bold commentators have, therefore, held that at the epoch of Hecatæus (which was that of Alexander the Great) the telescope was in very widespread use at the north of the European continent. But let us pass on to historic reality.

The English, through a feeling of national vanity, have put forward Roger Bacon (1267). This great man seems to have believed in the possibility of an instrument that could bring objects near to the eye by increasing their apparent dimensions, but all that he has said upon the subject may be taken for a simple *jeu d'esprit* merely. Roger Bacon certainly never constructed a telescope; but this detracts nothing from his fame, since he has, without anything being added thereto, sufficient claims upon the admiration of posterity.

Italy, the cradle of the revival of arts, sciences, and letters, has, on her side, upheld the candidature of Porta, the author of the *Magia Naturalis* (1589). Porta was, in fact, a very original genius, as is proved by the works that he has left; but he had one deplorable failing—that of never citing the sources whence he drew the facts that he gives as coming from his own stock.

We have said that, at the epoch of this learned Italian (toward the end of the sixteenth century), it was well known what advantages could be obtained by the superposition of two lenses, one concavo-concave and the other convexo-convex; they had already been set forth by Fracastoreus in 1538. Not only was Porta not the author of this discovery, but the rapid way in which he skims over the subject permits us to conclude that he had not made himself aware of the importance of the thing and the consequences to which it could lead.

Finally, toward the same epoch, Thomas, the son of Leonard Diggs, published a second edition of a work composed by his father, and entitled *Pantometry*. Leonard Diggs, who was born at Bristol, where he died in 1573, had, according to his son, succeeded in combining two lenses in such a way as to render the most distant objects distinct. Brewster has even taken this story of the son's as a basis for attributing the paternity of the invention to the father. But, once again, there was a wide gap between that quite general learning that formed a part of science at this epoch and the invention of the telescope. As for the reproach that has been cast upon Thomas Diggs of having borrowed from Porta, that falls when we come to compare the dates of publication of the two works. The *Pantometry* (first edition) is dated 1571, while the complete edition of the *Magia Naturalis* is dated 1589. The most that can be done is to trace back to Diggs the origin of what we find in Porta's works upon the subject of the telescope.

It results, from what we have seen up till now, that the telescope did not originate in the sixteenth century, although the properties of a concave and convex lens combined were known at that epoch. Let us recall, too, that a certain advantage had been derived therefrom, since the first eye-glasses date from that epoch, as we learn from some passages in the work of Porta, and in that of Gaspard Schott, the *Magia Universalis Naturæ et Artis.*

The great discovery was reserved for the first years of the seventeenth century. It was to be followed by incalculable results; it was to give the last blow to the cosmogonic systems of the ancients and of Tycho Brahe, to give astronomical science a new impetus, and permit mankind to judge of its true place in the universe.

II.

Descartes, to whom we are indebted for the true laws of the refraction of light, wrote in his *Dioptrics* in 1637: "To the disgrace of our sciences, this invention (that of the telescope), which is so useful and admirable, was primarily discovered merely by experiment and chance. It was about thirty years ago that a person named Jacques Metius, of the city of Alkmaar, Holland, a man who had never studied (although he had a father and brother who professed to understand mathematics), but who took particular pleasure in making mirrors and burning lenses of ice in winter, as experiment has shown that they can be so made, having on one occasion several lenses of various forms, took a notion, by good luck, to look through two, one of which was a little thicker in the middle than at the edges, and the other, on the contrary, much thicker at the edges than in the center; and these he applied so felicitously to the end of a tube as to form the first telescope of which we are speaking."

This passage from Descartes' *Dioptrics* has long been admitted as evidence, especially among French writers, and upon its authority the priority of the invention has been attributed to Metius. There is nothing in this, however; and what is to be remarked in these lines is the part that Descartes accords to accident in the discovery. It is quite astonishing that so distinguished a mind could content itself with such explanations. The great geometer, who was better posted than any one else on the scientific attainments of his time, seems here to put forth an opinion upon a subject on which he had but slightly reflected. He seems, moreover, to have received very scant information only as to the author and the mode of the discovery.

We now reach the years bordering on 1608, the epoch at which the first telescopes made their appearance. The noise made over this event well showed what importance the scientific world of the period attached to it. The ambassadors of France to the States General informed Henri IV. of it, all scientific Germany interested itself in it, Kepler at once outlined dioptrics, Descartes caused it to take a decisive step, and, finally, Galileo improved the new instrument and pointed out its great range.

But, at this epoch, the name of the true inventor was already enveloped in darkness. It was well known that the fortunate discoverer was Dutch, and it was even believed that he belonged in Middelbourg, and was by his profession naturally led to study the wonders of optics, since he was credited with being a spectacle maker. But the facts, meanwhile, were not put together with precision, and the curious of the period were inquiring for the truth of the details.

Up to 1831, a letter from Guillaume Borelius (ambassador of the States General) to Pierre Borellus* was the principal document upon which commentators relied. Borelius, a physician to the king, had asked Borelius to furnish him with such details as he possessed in regard to the new invention.

The Dutch ambassador, who was born at Middelbourg, ought, better than any one else, to have been able to satisfy him. Borelius' letter is too lengthy to reproduce in this place, and we shall be content to recapitulate the principal points of it. According to Borelius, the true inventors of the telescope were two spectacle makers of Middelbourg, Hans and his son Zacharias. When a child, says Borelius, I played with young Zacharias, and remember passing hours at a time in his father's shop. It is related that Hans and his son first invented a microscope, which they presented to Prince Maurice of Nassau. Later on, Archduke Albert likewise received one from their hands. In 1619, while ambassador to England, continues Borelius, I met a Dutchman from Alkmaar named Cornelius Drebelius, a mathematician to King James, who showed me the last-mentioned microscope, which the archduke had presented to him.

It was not till 1610 that Zacharias invented the astronomical telescope; and, as soon as the report of the discovery spread, people flocked to Middelbourg from all quarters. A Dutchman, whose name I know not, upon reaching the city, and not knowing where the inventor lived, visited the house of one of the latter's neighbors, who likewise was a spectacle maker. This man made the stranger believe that he was the true inventor, and, thanks to his quick wit, and his general knowledge of Zacharias' invention, as well as to his daily conversations with the inventor, he succeeded in thoroughly satisfying his customer, and in constructing perfect instruments for him. After this, he was reputed in the country to be the author of the discovery.

This error was unmasked later on, in 1620, when Adrien Metius and Cornelius Drebelius went to Middelbourg and entered into relations with Zacharias Johannides.

There are several points to be called attention to in these passages from Borelius' letter. The microscope which he speaks of as being of Zacharias' invention was certainly not the instrument that we now call by that name; and the best proof of this is a description which is given in the letter, but which we have not reproduced. In the second place, we get a glimpse of the cause that led Descartes to attribute the paternity of the astronomical telescope to Metius.

It is not surprising that so clear and important testimony was for a long time law. On another hand, one very valid document gives Laprey (sometimes called Lippershey) as the true inventor. This is a declaration signed by the aldermen of the commune of Middelbourg, dated 1655. These magistrates had summoned before them three old men, Jacob Wilhelm, Adolphe Kien, and Abraham Junius, in order to obtain some light upon a question that so much interested the city's honor. The testimony of these men agreed in attributing the priority of the invention to Jean Laprey. Borelius' error can be accounted for only by the fact of the similarity of the Christian names by which persons were often designated at this epoch. It is true that another document, which appears to be just as valid, gives us, likewise under the seal of the same commune, Jean and Zacharias as the true inventors, and consequently confirms Borelius' letter.

The question was therefore undecided, and remained in the same state for many years; and so, both in Holland and foreign countries, the most contradictory opinions have been put forth as to the inventor of the telescope.

The news of the discovery did not excite the same curiosity in all. As we have already hinted, Jeanin and Russy, the French ambassadors to the States General, hastened in 1608 to announce to Henri IV. the great news that was agitating entire Holland, and informed him that they were going to do their utmost to procure the wonderful instrument for him. The king's answer, dated January 8, 1609, was quite curt: "I shall take pleasure," it reads, "in seeing the eye-glass* that your letter mentions, although just now I have greater need of such as will aid in seeing close by than to a distance."

Galileo received the news like a true scientist and perspicacious genius. An interesting chapter of history might be composed in showing the advantages that the great Florentine derived from the Middelbourg spectacle-maker's discovery, but we have neither time nor space for it. We shall be content to observe that Galileo, to whom also has been attributed the discovery, has acknowledged that he was not the inventor.

We are obliged to wait until the end of the first third of the nineteenth century in order to see the question of the origin of the telescope completely settled. We owe the solution to Van Swinden, professor of physics at Amsterdam, and to Prof. Moll, of Utrecht. The state archives have permitted of establishing the real rights of each, and of deciding between Hans and Zacharias and Laprey and the Metiuses. Van Swinden found a letter from Metius to the States, dated Oct. 17, 1608, in which he declares that for two years past he had devoted all his waking hours to the search for an instrument that should permit of bringing distant objects near by, and that he had finally succeeded in it. He adds that he thinks that he has been just as successful as the Middelbourg spectacle-maker, who had just made known a similar invention. The question was therefore decided in favor of the citizens of the Dutch city. A second document, which was found at Hague, decided between the two remaining contestants. This document is a petition of Jean Lippershey's (born at Wesel, and a spectacle-maker at Middelbourg) to the States General, requesting a thirty years' patent for his invention. In the papers thereto annexed, the States certify that they will be ready to comply with his request when he succeeds in rendering his instrument capable of being used with both eyes. Later on, they waived this clause, and named a committee, composed of individuals selected from all the provinces, to decide upon the value of Lippershey's invention. The experiments were performed at the top of the tower of Prince Maurice's palace, and entirely satisfied the committee. The inventor received an order to construct, on the States' account, two binocular instruments, whose lenses should be of rock crystal, and for which he was to be paid 900 guilders. As for a patent, that was refused him, under the pretext that the invention was already so widely spread that protection could not be guaranteed it.

The true inventor of the telescope, then, is Lippershey, a Middelbourg spectacle-maker, and the date of the invention can be fixed with certainty at 1608.

* In *Ciel et Terre.*

* Inserted in Borelius' "De vero telescopu inventore."

* In order to make the king's allusion to the instrument understood, it should be stated that "eye-glass" and "telescope" are expressed by the same word in French, viz., *lunette.*

AGRICULTURAL EXPERIMENTS.†

By R. ROMANIS.

TEN plats were manured with ground bones, dissolved bones, and niter for three years. The result shows that ground bones are the most economical manure for rice in the soil of the Irrawadi delta. The largest crop was given by a mixture of 10 cwt. ground bones with 1½ cwt. niter per acre, viz., 2,890 lb. of grain against 1,940 lb. by the unmanured.

Composition of Grain Grown with Various Manures.

	I. 2 years unmanured.	II. 1st year, Ground Bones. 2d year, No manure.	III. Bones, 2 years.
Cellulose	10·78	10·10	8·94
Alkaline extract	13·20	12·30	10·43
Alcoholic extract	2·24	1·20	1·93
Water extract	2·35	2·87	2·23
Benzol extract	4·93	2·18	3·31
Starch	66·72	70·60	73·13

Ash of Rice. (By J. TSAW OS WHITE.)

	Unhusked.	Husked.
Potash	7·35	16·99
Soda	0·53	2·03
Lime	0·66	1·19
Magnesia	3·03	11·76
Ferric oxide	2·46	2·38
Phosphoric acid	10·65	45·96
Silicic acid	75·32	19 69

Ash of Indigo Stem.

Potash	42·22
Soda	5·97
Lime	18·54
Magnesia	6·27
Ferric oxide	1·06
Phosphoric acid	12·55
Sulphuric acid	8·45
Silicic acid	4·92

† Notes from the Laboratory of the Chemical Examiner to the Government, Burma.

Ash of Juice of Sugar-Cane Grown at Two Different Localities.

	I.	II.
Potash	33·80	36·09
Soda	19·40	2·25
Magnesia	1·42	7·81
Lime	1·38	1·39
Ferric oxide	1·59	2·17
Phosphoric acid	3·92	11·32
Sulphuric acid	35·33	23·24
Silicic acid	3·33	9·46
Chloride of potassium	·00	6·24
	100	100

No. 1 came from a district near the sea; the sugar is said not to crystallize. No. 2 is the same cane grown at Rangoon; it crystallized without difficulty.

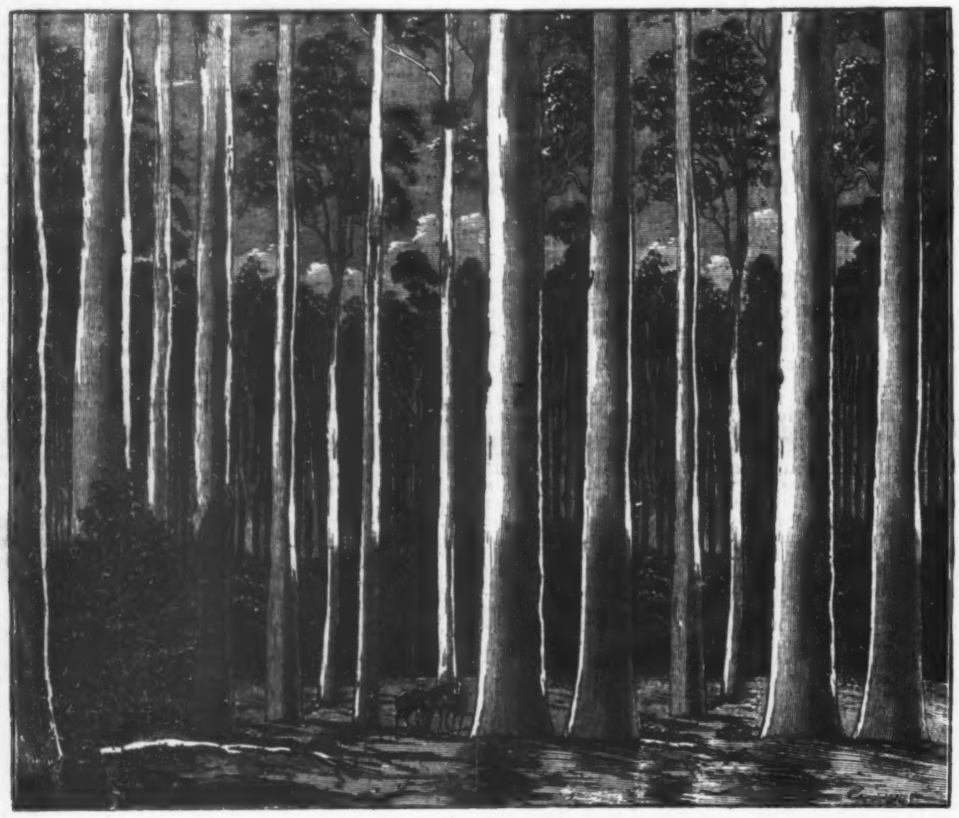
ANALYSIS OF JADE FROM BURMAH.

Specimen of Jade from Mogaung, found in the Palace at Mandalay. (By J. T. Os White.)

Silica	49·13
Alumina	19·26
Ferrous oxide	6·56
Lime	11·33
Magnesia	5·80
Potash	0 91
Soda	7·07
	100·06

AMONG THE GUMS AND TURPENTINES.

DURING a recent excursion of one of our artists along that portion of the Northern railway route lying between Gosford and Lake Macquarie, New South Wales, he was astonished at the wealth of timber that will become marketable when the railway is open. Our New South Wales friends are importing large quantities of lumber every week, though there is, comparatively near, growing timber equal to any in the world. At Gillaby Gillaby, where the view given above was taken, forests of gum trees or eucalypti may be seen towering as high as 200 feet, and of as much as 15 feet diameter, without a branch for 50 or 60 feet. The turpentine trees are equally remarkable in appearance, as it would be difficult to find a crooked trunk within hundreds of yards of any point. The latter trees have not yet been sufficiently appreciated, though several years ago the late Captain Shoobert announced the fact that it is the only indigenous timber New South Wales has possessing the merit of being impervious to the attacks of the *Teredo navalis*. This he proved most conclusively, and latterly almost every new wharf constructed in and about Sydney stands upon turpentine piles.



AUSTRALIAN GUM TREES.

When means of transportation by rail become available, those who are fortunate enough to have land timbered with this invaluable tree will have reason to congratulate themselves on their good fortune. In South Australia we have some splendid timber, though not of so great a size as that growing in Gippsland, Victoria, and in various parts of New South Wales. The white gum, found growing in the southeast part of this province, also at Echunga in the Valley of the Onkaparinga, and in other parts of the colony, is probably the tallest tree we possess. Its height varies from 70 to 140 feet. In West Australia the jarrah reaches 200 feet in height.—*Pictorial Australian.*

M. MANASSEIN, a physician of St. Petersburg, avers that cocaine is unequaled in seasickness. He also finds it effective in cholera morbus, and thinks it will prove a great remedy for Asiatic cholera.

SENOR CASTELAR.

CASTELAR is known throughout Europe as really the most complete expression of Spanish eloquence. He carries his worship of form almost to idolatry; his eloquence is music, his diction the slave of his ear. He says or does not say a thing; or, rather, he says it better in one sense than in another, according as it rounds or does not round a period. He has a harmony in his mind; he follows, obeys it, and sacrifices to it all that offends. His periods are strophes; it is necessary to hear in order to believe that human language without poetic measure can thus approach the harmony of poesy and of song. He is more the artist than the politician; he has not only the genius but the heart of the artist—the heart of a child, incapable of enmity or of malice. In all his speeches there is not to be found an abusive epithet; in the Cortes he has never provoked a serious personal encounter; has never recourse to a satire, nor ever makes use of irony. Into his most violent philippics he never infuses a drop of gall; and this is evidence of the fact that a republican, an opponent of every ministry, a journalistic gladiator, the perpetual accuser of whomsoever holds power, and of all who are not fanatical for liberty, he has made himself hated by no one. And, with all this, his speeches are enjoyed and never feared; his language is too beautiful to be terrible, his character too ingenuous for him to exercise a political influence. He does not know how to fence, to plot, to trim his sails—he is fitted only to please and to shine. His eloquence, when greatest, is tender; his most beautiful discourses draw tears. For him the chamber is a theater; like a political improvisatore, in order to have a full and calm inspiration he must speak at a certain hour, upon a determined point, and with an allotted time of liberty to himself. For this reason, the day on which he is to speak he has an understanding with the president of the Chamber that his turn will come when the galleries are most crowded and all the deputies are in their places, his own paper announcing his speech the evening previous, in order that ladies may be able to provide themselves with tickets. He has need of this excitement. Before speaking he is uneasy, and cannot remain still for an instant. He enters the Chamber, leaves it, re-enters, turns to go out, takes the round of the corridors and library, where he turns over the leaves of a volume—in a word, he is in a fever of excitement. It seems to him as if he could not utter a syllable—that he must excite ridicule, and be hissed. In his mind no longer remains a single lucid idea of his speech; everything is confused; everything forgotten. "How is your pulse?" his friends inquire of him, with a smile. The supreme moment arrived, he springs to the floor, with head bent, pale and trembling, like a criminal about to be executed, resigned to lose in a single moment the glory acquired through so many years, and with such indefatigable labor. At this instant, an enemy even would compassionate his condition. He rises, throws a rapid glance around him, and speaks: "Senores!" He is safe; his courage is restored to him; his brain is again unclouded; his speech rearranges itself in his mind like a long forgotten melody. The president, the Cortes, the galleries, disappear; he sees only his own gestures; hears only his own voice; feels but the irresistible flame that enkindles the force of his own matchless eloquence. It is beautiful to hear him say of himself: "I do not see the walls of the apartment, even. I behold distant lands and peoples which I have never seen before." He speaks for hours together, and not a deputy leaves the hall, not a voice interrupts, not a movement distracts him. Not even when he violates parliamentary rules has the president the courage to interrupt him. Clad in robes of dazzling whiteness, and crowned with roses, he portrays at will the image of *his republic;* and monarchists do not venture to protest, for thus arrayed they even find her beautiful. Castelar is lord of the assembly. He flashes and fulminates, scintillates and beams like a *feu d'artifice;* he provokes a smile or he calls forth enthusiastic shouts, ending in the midst of an outburst of applause, and vanishing from the Chamber with his head in the clouds. Such is this famous Castelar, professor of history in the university, a most prolific writer on politics, art, and religion, a publicist who draws from American journals ten thousand dollars yearly; an academician, unanimously elected by the Spanish Academy, pointed out in the thoroughfares, feted by the populace, loved by even his opponents; a young man, polished, generous, a little vain, and a favorite of Fortune.—*Translated for Public Opinion from the Italian of Edwara's Amices.*

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